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GROUP 16

ENGINE ELECTRICAL

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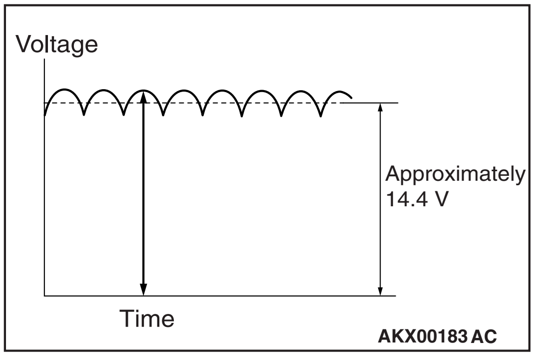
CHARGING SYSTEM

GENERAL INFORMATION

M1161000100867

The charging system uses the alternator output to keep the battery charged at a constant level under various electrical loads.

OPERATION



Rotation of the excited field coil generates AC voltage in the stator.

This alternating current is rectified through diodes to DC voltage having a waveform shown in the illustration.

The average output voltage fluctuates slightly with the alternator load condition.

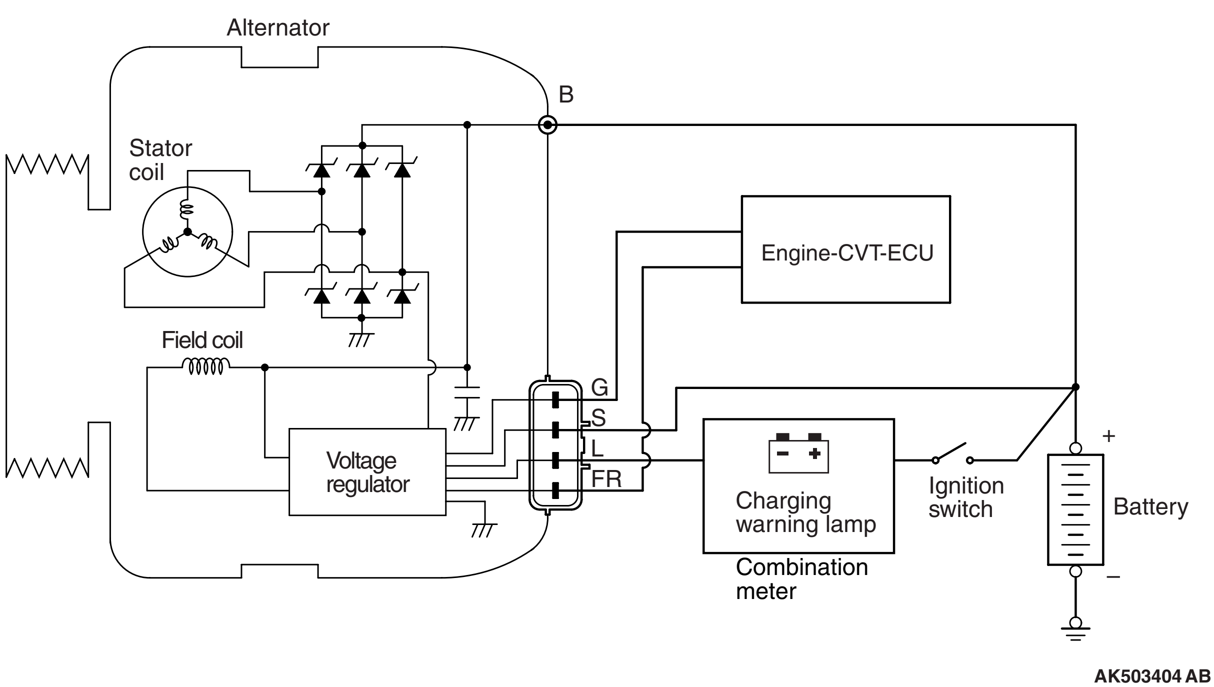
When the ignition switch is turned on, current flows in the field coil and initial excitation of the field coil occurs.

When the stator coil begins to generate power after the engine is started, the field coil is excited by the output current of the stator coil.

The alternator output voltage rises as the field current increases and it falls as the field current decreases. When the battery voltage (alternator "S" terminal voltage) reaches a regulated voltage of approximately 14.4 V, the field current is cut off. When the battery voltage drops below the regulated voltage, the voltage regulator regulates the output voltage to a constant level by controlling the field current.

In addition, when the field current is constant, the alternator output voltage rises as the engine speed increases.

SYSTEM DIAGRAM



ALTERNATOR SPECIFICATIONS

Item	Specifications
Type	Battery voltage sensing
Rated output V/A	12/85
Voltage regulator	Electronic built-in type

SERVICE SPECIFICATIONS

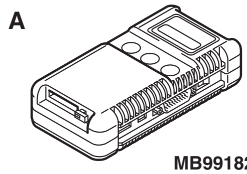
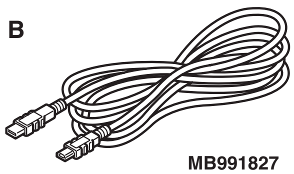
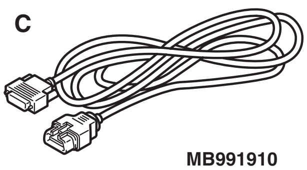
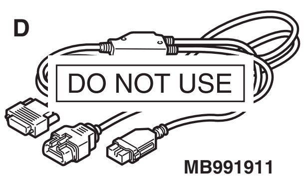
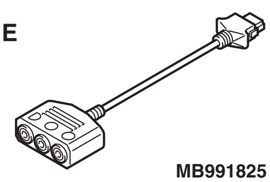
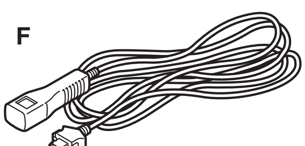
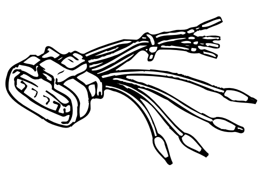
M1161000300708

Item		Standard value	Limit
Alternator output line voltage drop (at 30 A) V		–	maximum 0.3
Regulated voltage ambient temperature at voltage regulator V	–20°C	14.2 – 15.4	–
	20°C	13.9 – 14.9	–
	60°C	13.4 – 14.6	–
	80°C	13.1 – 14.5	–
Output current		–	70 % of normal output current
Field coil resistance Ω		3 – 5	–

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SPECIAL TOOL

M1161000600668

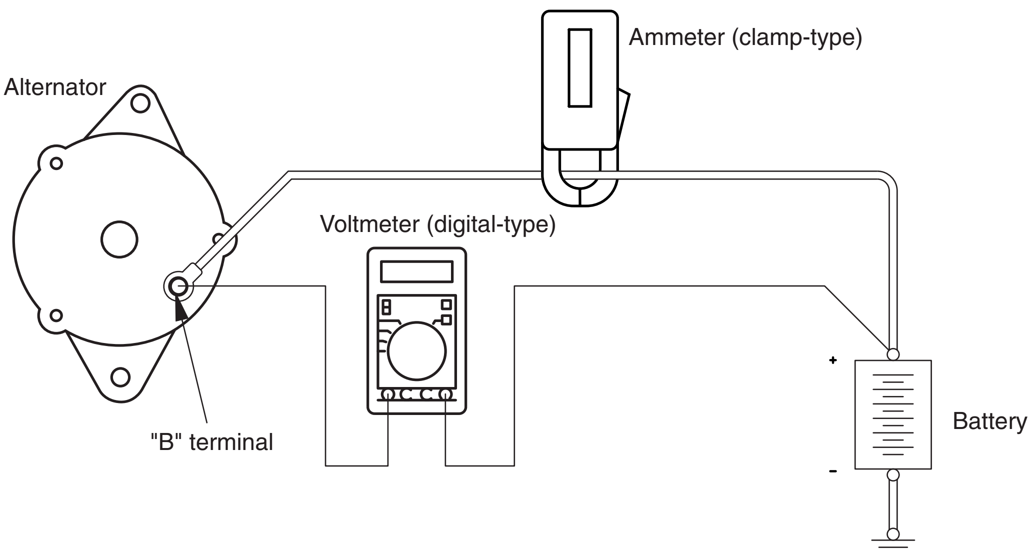
Tool	Number	Name	Use
A  MB991824 B  MB991827 C  MB991910 D  MB991911 E  MB991825 F  MB991826 MB991955	MB991955 A: MB991824 B: MB991827 C: MB991910 D: MB991911 E: MB991825 F: MB991826	M.U.T.-III sub assembly • A: Vehicle communication interface (V.C.I.) • B: M.U.T.-III USB cable • C: M.U.T.-III main harness A (Vehicles with CAN communication system) • D: M.U.T.-III main harness B (Vehicles without CAN communication system) • E: M.U.T.-III measurement adapter • F: M.U.T.-III trigger harness	• Checking the idle speed ⚠ CAUTION **For vehicles with CAN communication, use M.U.T.-III main harness A to send simulated vehicle speed. If you connect M.U.T.-III main harness B instead, the CAN communication does not function correctly.**
	MB991519	Alternator test harness	Checking the alternator ("S" terminal voltage)

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ON-VEHICLE SERVICE

ALTERNATOR OUTPUT LINE VOLTAGE DROP TEST

M1161000900982



This test determines whether the wiring from the alternator "B" terminal to the battery (+) terminal (including the fusible line) is in a good condition or not.

1. Always be sure to check the following before the test.
   - Alternator installation
   - Drive belt tension

(Refer to GROUP 11A – On-vehicle Service – Drive Belt Tension Check and Adjustment P.11A-6). <4A9>

(Refer to GROUP 11C – On-vehicle Service – Drive Belt Tension Check and Adjustment P.11C-8). <4G1>

   - Fusible link
   - Abnormal noise from the alternator while the engine is running
2. Turn the ignition switch to the "LOCK" (OFF) position.
3. Disconnect the negative battery cable.
4. Connect a clamp-type DC test ammeter with a range of 0 – 120 A to the alternator "B" terminal output wire.

   NOTE: The way of disconnecting the alternator output wire and of connecting the ammeter is possibly not found the problem that the output current is dropping due to the insufficient connection between terminal "B" and the output wire.
5. Connect a digital-type voltmeter between the alternator "B" terminal and the battery (+) terminal. [Connect the (+) lead of the voltmeter to the "B" terminal and the connect the (–) lead of the voltmeter to the battery (+) cable].
6. Reconnect the negative battery cable.
7. Connect the M.U.T.-III (to show the engine speed).
8. Leave the hood open.
9. Start the engine.
10. With the engine running at 2,500 r/min, turn the headlamps and other lamps on and off to adjust the alternator load so that the value displayed on the ammeter is slightly above 30 A.

    Adjust the engine speed by gradually decreasing it until the value displayed on the ammeter is 30 A. Take a reading of the value displayed on the voltmeter at this time.

    Limit: maximum 0.3 V

    NOTE: When the alternator output is high and the value displayed on the ammeter does not decrease until 30 A, set the value to 40 A. Read the value displayed on the voltmeter at this time. When the value range is 40 A, the limit is maximum 0.4 V.

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11.If the value displayed on the voltmeter is above the limit value, there is probably a malfunction in the alternator output wire, so check the wiring between the alternator "B" terminal and the battery (+) terminal (including fusible link).

If a terminal is not sufficiently tight or if the harness has become discolored due to overheating, repair and then test again.

12.After the test, run the engine at idle.

13.Turn the ignition switch to the "LOCK" (OFF) position.

14.Remove the M.U.T.-III.

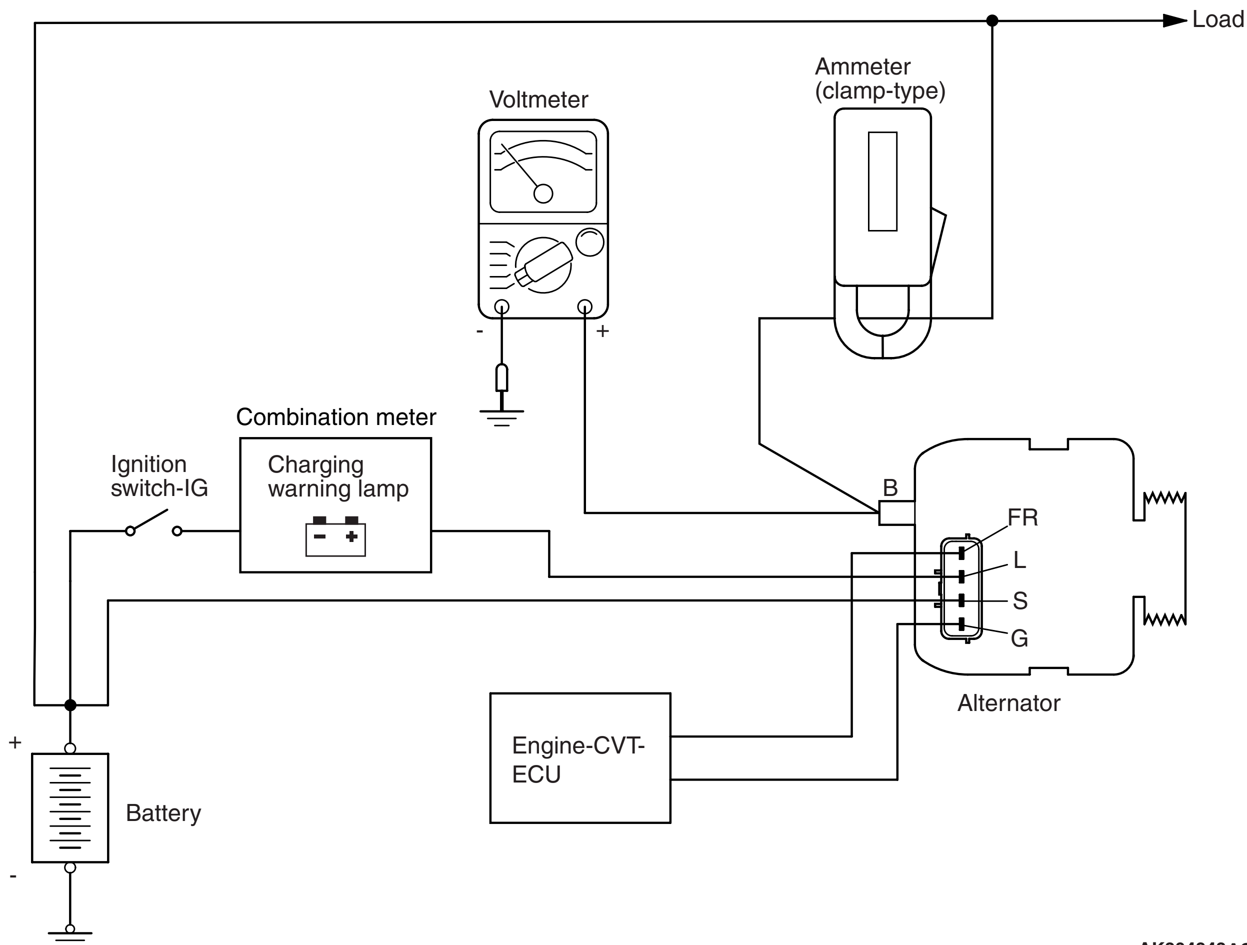
15.Disconnect the negative battery cable.

16.Disconnect the ammeter and voltmeter.

17.Connect the negative battery cable.

OUTPUT CURRENT TEST

M1161001001026



AK304843AC

This test determines whether the alternator output current is normal.

1. Before the test, always be sure to check the following.
   - Alternator installation
   - Battery (Refer to GROUP 54A – Battery – On-vehicle Service P.54A-5).

NOTE: The battery should be slightly discharged. The load needed by a fully-charged battery is insufficient for an accurate test.

   - Drive belt tension

(Refer to GROUP 11A – On-vehicle Service – Drive Belt Tension Check and Adjustment P.11A-6). <4A9>

(Refer to GROUP 11C – On-vehicle Service – Drive Belt Tension Check and Adjustment P.11C-8). <4G1>

   - Fusible link
   - Abnormal noise from the alternator while the engine is running.

2. Turn the ignition switch to the "LOCK" (OFF) position.
3. Disconnect the negative battery cable.

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⚠ CAUTION

Never use clips but tighten bolts and nuts to connect the line. Otherwise loose connections (e.g. using clips) will lead to a serious accident because of high current.

4. Connect a clamp-type DC test ammeter with a range of 0 – 120 A to the alternator "B" terminal output wire.

   NOTE: The way of disconnecting the alternator output wire and of connecting the ammeter is possibly not found the problem that the output current is dropping due to the insufficient connection between terminal "B" and the output wire.

5. Connect a voltmeter with a range of 0 – 20 V between the alternator "B" terminal and the earth [Connect the (+) lead of the voltmeter to the "B" terminal, and then connect the (–) lead of the voltmeter to the earth].
6. Connect the negative battery cable.
7. Connect the M.U.T.-III (to show the engine speed).
8. Leave the hood open.
9. Check that the reading on the voltmeter is equal to the battery voltage.

   NOTE: If the voltage is 0 V, the cause is probably an open circuit in the wire or fusible link between the alternator "B" terminal and the battery (+) terminal.

10. Turn the light switch on to turn on headlamps and then start the engine.
11. Immediately after setting the headlamps to high beam and turning the heater blower switch to the high revolution position, increase the engine speed to 2,500 r/min and read the maximum current output value displayed on the ammeter.

    Limit: 70 % of normal current output

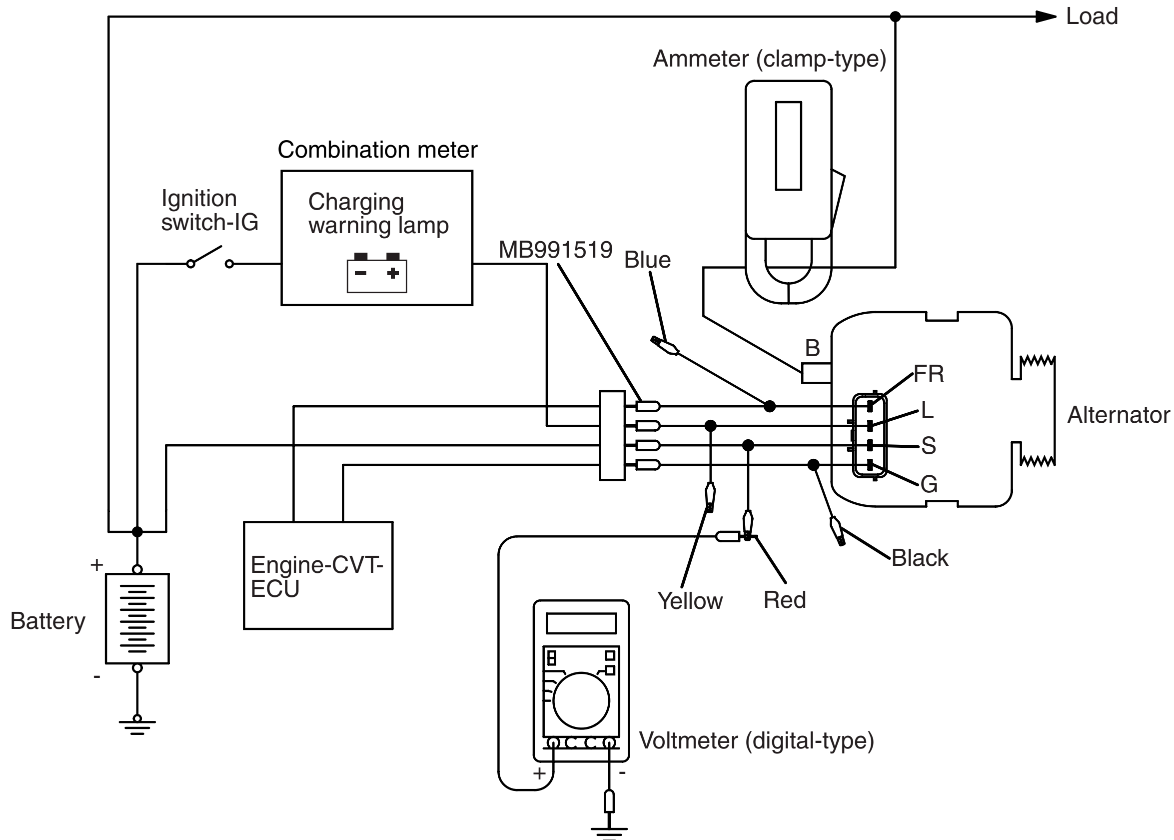
    NOTE:
    - *For the nominal current output, refer to the Alternator Specifications.*
    - *Because the current from the battery will soon drop after the engine is started, the above step should be carried out as quickly as possible in order to obtain the maximum current output value.*
    - *The current output value will depend on the electrical load and the temperature of the alternator body.*
    - *If the electrical load is small while testing, the specified level of current may not be output even though the alternator is normal. In such cases, increase the electrical load by leaving the headlamps turned on for some time to discharge the battery or by using the lighting system in another vehicle, and then test again.*
    - *The specified level of current also may not be output if the temperature of the alternator body or the ambient temperature is too high. In such cases, cool the alternator and then test again.*

12. The reading on the ammeter should be above the limit value. If the reading is below the limit value and the alternator output wire is normal, remove the alternator from the engine and check the alternator.
13. Run the engine at idle after the test.
14. Turn the ignition switch to the "LOCK" (OFF) position.
15. Remove the M.U.T.-III.
16. Disconnect the negative battery cable.
17. Disconnect the ammeter and voltmeter.
18. Connect the negative battery cable.

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REGULATED VOLTAGE TEST

M1161001101089



AK304844 AJ

This test determines whether the voltage regulator correctly controlling the alternator output voltage.

1. Always be sure to check the following before the test.
   - Alternator installation
   - Check that the battery installed in the vehicle is fully charged.

(Refer to GROUP 54A – Battery – On-vehicle Service – Charging P.54A-4).

   - Drive belt tension

(Refer to GROUP 11A – On-vehicle Service – Drive Belt Tension Check and Adjustment P.11A-6). <4A9>

(Refer to GROUP 11C – On-vehicle Service – Drive Belt Tension Check and Adjustment P.11C-8). <4G1>

   - Fusible link
   - Abnormal noise from the alternator while the engine is running

2. Turn the ignition switch to the "LOCK" (OFF) position.
3. Disconnect the negative battery cable.
4. Use the special tool Alternator test harness (MB991519) to connect a digital voltmeter between the alternator "S" terminal and earth [Connect the (+) lead of the voltmeter to the "S" terminal, and then connect the (–) lead of the voltmeter to a secure earth or to the battery (–) terminal].
5. Connect a clamp-type DC test ammeter with a range of 0 – 120 A to the alternator "B" terminal output wire.

   NOTE: The way of disconnecting the alternator output wire and of connecting the ammeter is possibly not found the problem that the output current is dropping due to the insufficient connection between terminal "B" and the output wire.

6. Reconnect the negative battery cable.
7. Connect the M.U.T.-III (to show the engine speed).
8. Turn the ignition switch to the "ON" position and check that the reading on the voltmeter is equal to the battery voltage.

   NOTE: If the voltage is 0 V, the cause is probably an open circuit in the wire or fusible link between the alternator "S" terminal and the battery (+) terminal.

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9. Turn all lamps and accessories off.
10. Start the engine.
11. Increase the engine speed to 2,500 r/min.
12. Read the value displayed on the voltmeter when the alternator output current alternator becomes 10 A or less.
13. If the voltage reading conforms to the value in the voltage regulation, then the voltage regulator is operating normally.

    If the voltage is not within the standard value, there is a malfunction of the voltage regulator or of the alternator.
14. After the test, lower the engine speed to the idle speed.
15. Turn the ignition switch to the "LOCK" (OFF) position.
16. Remove the M.U.T.-III.
17. Disconnect the negative battery cable.
18. Disconnect the ammeter and voltmeter.
19. Connect the alternator output wire to the alternator "B" terminal.
20. Remove the special tool, and return the connector to the original condition.
21. Connect the negative battery cable.

Voltage Regulation Table

Standard value:

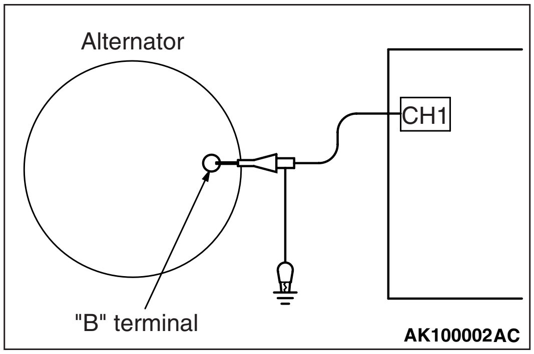
Inspection terminal	Voltage regulator ambient temperature °C	Voltage V
Terminal "S"	–20	14.2 – 15.4
	20	13.9 – 14.9
	60	13.4 – 14.6
	80	13.1 – 14.5

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WAVEFORM CHECK USING AN OSCILLOSCOPE

M1161001200373

MEASUREMENT METHOD

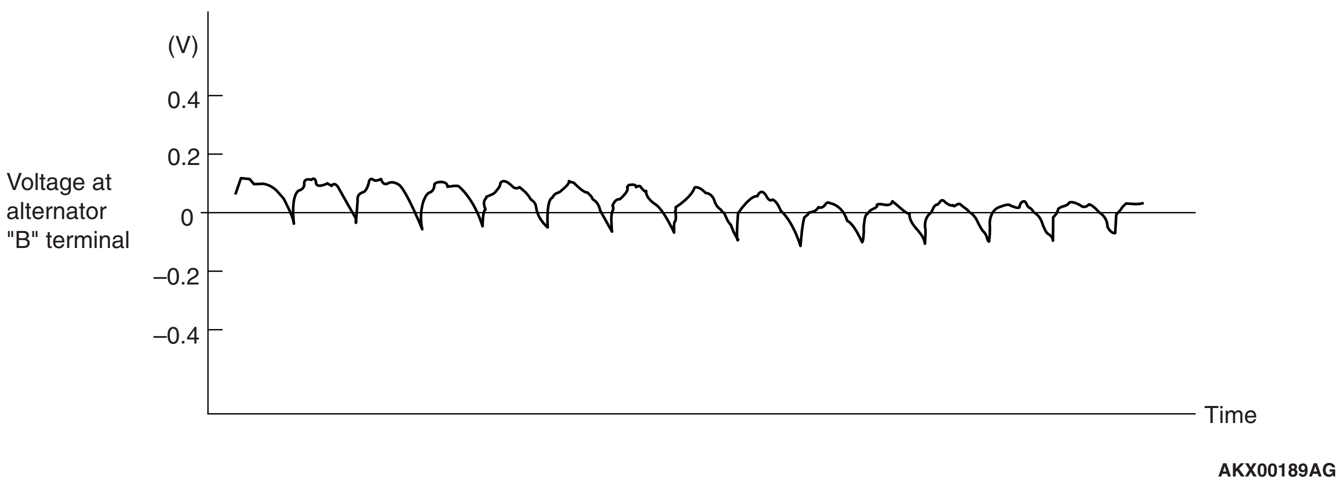


Connect the oscilloscope special patterns pick-up to the alternator "B" terminal.

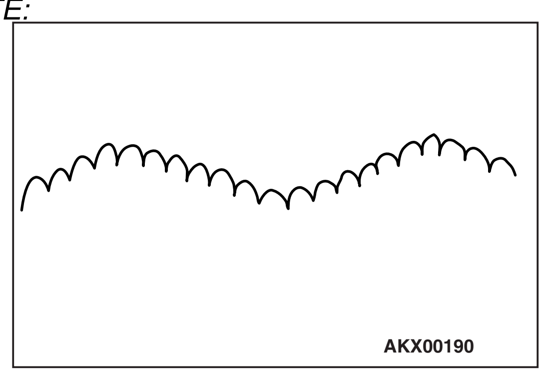
STANDARD WAVEFORM

Observation Conditions

Function	Special pattern
Pattern height	Variable
Variable knob	Adjust while viewing the waveform.
Pattern selector	Raster
Engine speed	Curb idle speed



NOTE:



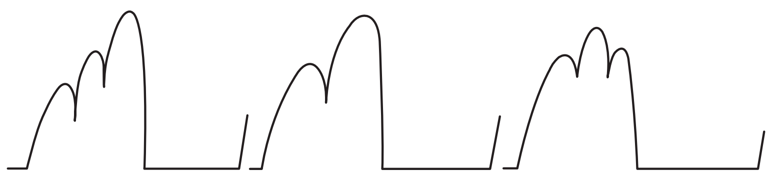
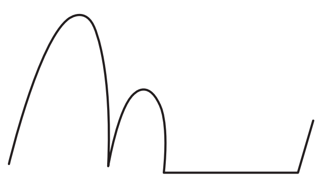
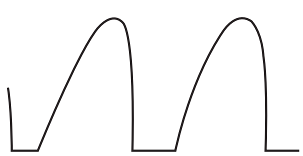
The voltage waveform of the alternator "B" terminal can undulate as shown in the illustration. This waveform is produced when the regulator operates according to fluctuations in the alternator load (current), and is normal for the alternator. In addition, when the voltage waveform reaches an excessively high value (approximately 2 V or higher at idle), it often indicates an open circuit due to a brown fuse between alternator "B" terminal and battery, but not a defective alternator.

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EXAMPLE OF ABNORMAL WAVEFORMS

NOTE:

1. *The size of the waveform patterns differs largely, depending on the adjustment of the variable knob on the oscilloscope.*
2. *Identification of abnormal waveforms is easier when there is a large output current (regulator is not operating). (Waveforms can be observed when the headlamps are illuminated.)*
3. *Check the conditions of the charging warning lamp (illuminated/not illuminated). Also, check the charging system totally.*

Abnormal waveform	**Problem cause**
Example 1  AKX00191	Open diode
Example 2  AKX00192	Short in diode
Example 3  AKX00193	Broken wire in stator coil
Example 4  AKX00194	Short in stator coil

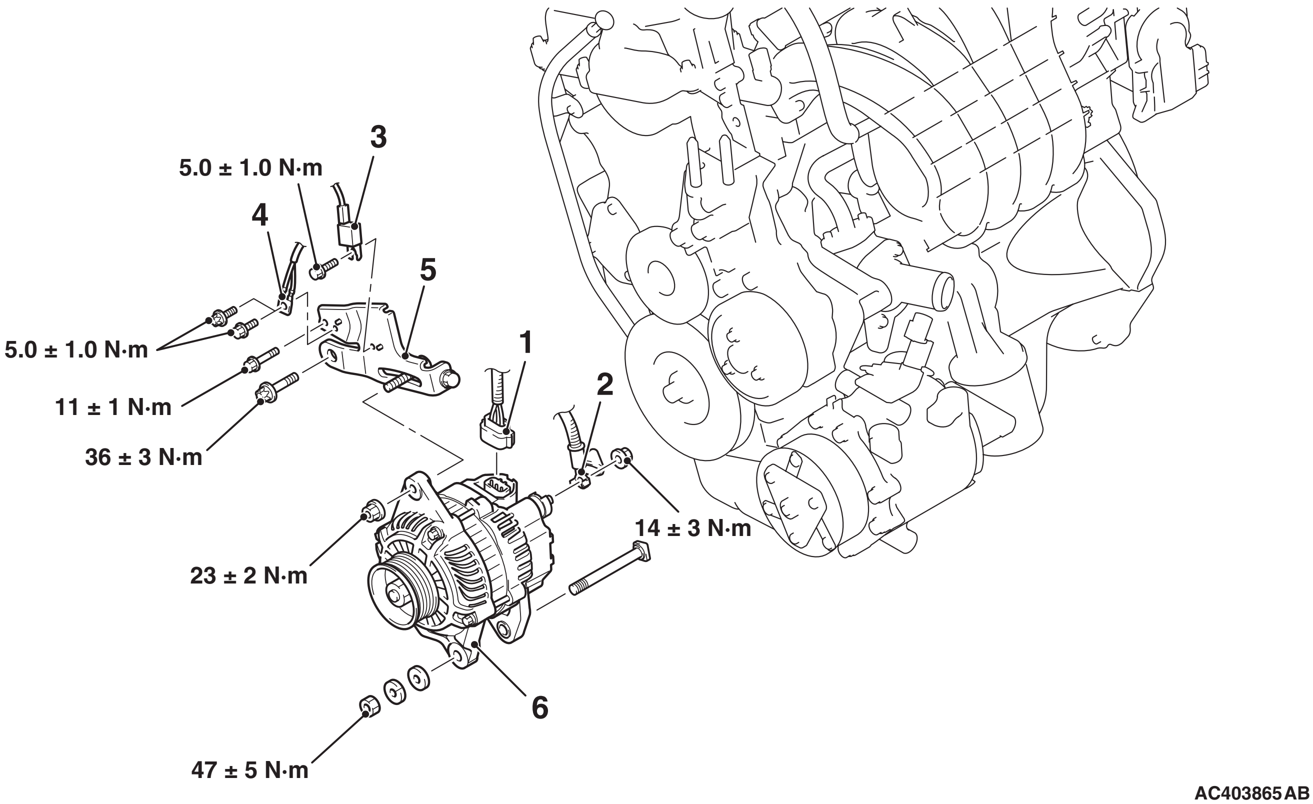
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ALTERNATOR ASSEMBLY

REMOVAL AND INSTALLATION <4A9>

M1161001401637

Pre-removal Operation	Post-installation Operation
• Engine Cover Removal (Refer to GROUP 11A, Camshaft P.11A-17). • Front Under Cover Panel Removal (Refer to GROUP 51, Front Bumper Assembly and Radiator Grille P.51-2). • Engine Coolant Draining (Refer to GROUP 14, On-vehicle Service – Engine Coolant Replacement P.14-4). • Radiator Lower Hose Removal (Refer to GROUP 14, Radiator P.14-22). • Drive Belt Removal (Refer to GROUP 11A, Crankshaft Pulley P.11A-14).	• Drive Belt Installation (Refer to GROUP 11A, Crankshaft Pulley P.11A-14). • Radiator Lower Hose Installation (Refer to GROUP 14, Radiator P.14-22). • Engine Coolant Refilling (Refer to GROUP 14, On-vehicle Service – Engine Coolant Replacement P.14-4). • Drive Belt Tension Check and Adjustment (Refer to GROUP 11A, On-Vehicle Service – Drive Belt Tension Check and Adjustment P.11A-6). • Front Under Cover Panel Installation (Refer to GROUP 51, Front Bumper Assembly and Radiator Grille P.51-2). • Engine Cover Installation (Refer to GROUP 11A, Camshaft P.11A-17).



Removal steps

1. Alternator connector
2. Alternator terminal
3. Noise condenser
4. Earth connection

Removal steps (Continued)

5. Alternator brace

<<**A**>> 6. Alternator assembly

REMOVAL SERVICE POINT

<<A>> ALTERNATOR ASSEMBLY REMOVAL

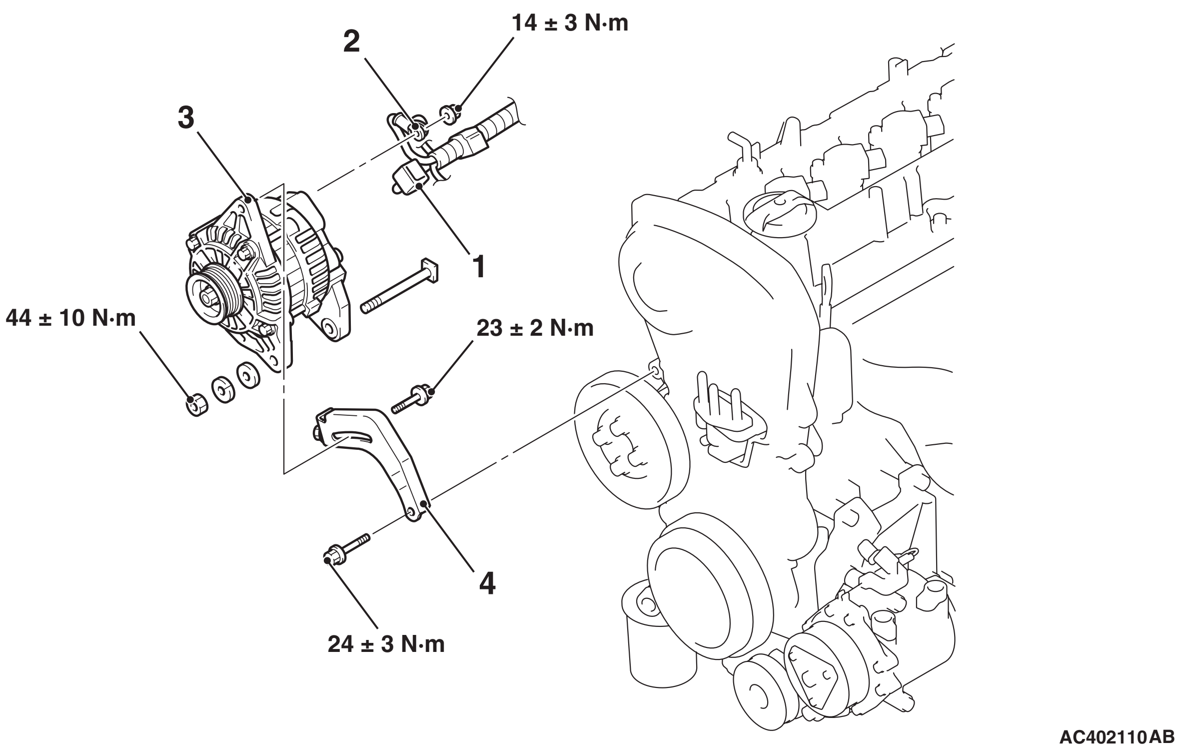
Remove the alternator assembly from above the vehicle.

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REMOVAL AND INSTALLATION <4G1>

M1161001401648

Pre-removal Operation	Post-installation Operation
• Engine Cover Removal (Refer to GROUP 11C, Camshaft and Valve Stem Seal P.11C-20). • Side Under Cover Panel (RH) Removal • A/C Compressor Drive Belt and Alternator Drive Belt Removal (Refer to GROUP 11C, Crankshaft Pulley P.11C-17). • Exhaust Centre Pipe and Exhaust Front Pipe Removal (Refer to GROUP 15, Exhaust Pipe and Main Muffler P.15-21). • Front Suspension Axle Side Plate Removal (Refer to GROUP 32, Front Axle Crossmember P.32-17). • Inlet Manifold Stay Removal (Refer to GROUP 15, Inlet Manifold P.15-12).	• Inlet Manifold Stay Installation (Refer to GROUP 15, Inlet Manifold P.15-12). • Front Suspension Axle Side Plate Installation (Refer to GROUP 32, Front Axle Crossmember P.32-17). • Exhaust Centre Pipe and Exhaust Front Pipe Installation (Refer to GROUP 15, Exhaust Pipe and Main Muffler P.15-21). • A/C Compressor Drive Belt and Alternator Drive Belt Installation (Refer to GROUP 11C, Crankshaft Pulley P.11C-17). • Drive Belt Tension Check and Adjustment (Refer to GROUP 11C, On-Vehicle Service – Drive Belt Tension Check and Adjustment P.11C-8). • Side Under Cover Panel (RH) Installation • Engine Cover Installation (Refer to GROUP 11C, Camshaft and Valve Stem Seal P.11C-20).



Removal steps

1. Alternator connector
2. Alternator terminal

Removal steps (Continued)

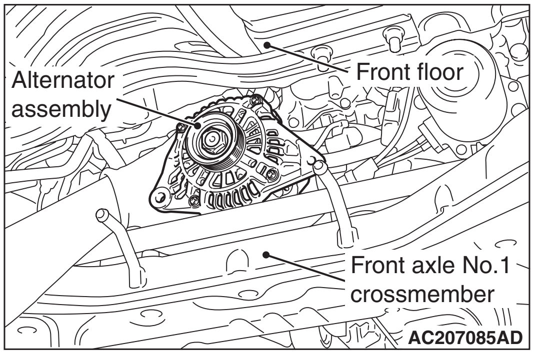
<<**A**>> 3. Alternator assembly

>>**A**<< 4. Alternator brace

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REMOVAL SERVICE POINT

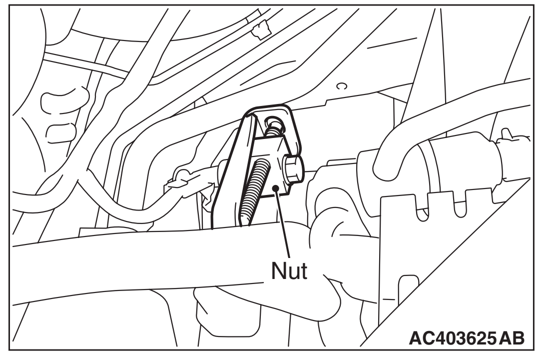
<<A>> ALTERNATOR ASSEMBLY REMOVAL



Remove the alternator assembly from between the front floor and the front axle No.1 crossmember.

INSTALLATION SERVICE POINT

>>A<< ALTERNATOR BRACE INSTALLATION

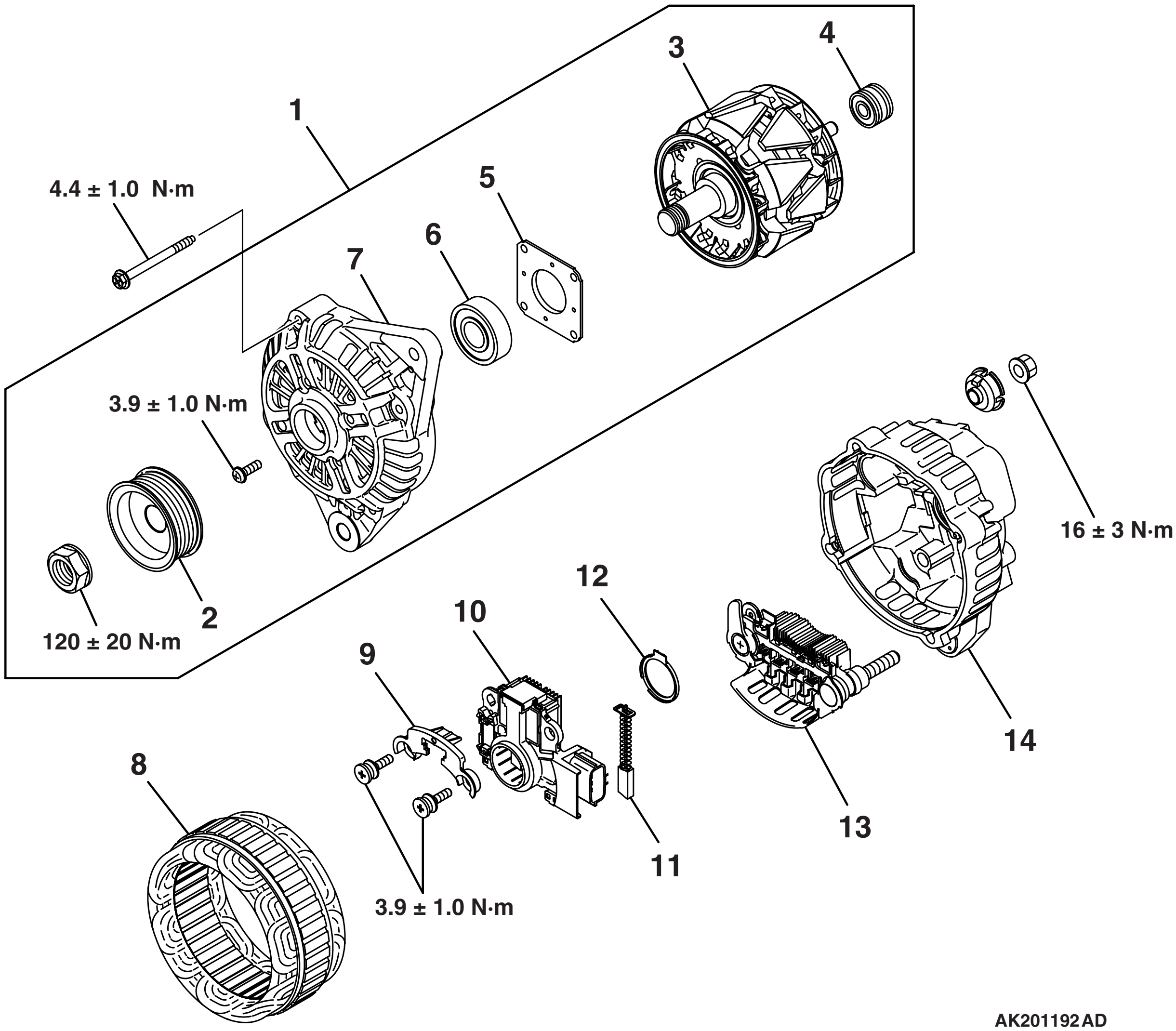


Install the alternator brace nut so that it is in the direction shown.

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DISASSEMBLY AND ASSEMBLY

M1161001600274



Disassembly steps

- <<**A**>> 1. Front bracket assembly
- <<**B**>> 2. Alternator pulley
- >>**B**<< 3. Rotor
- 4. Rear bearing
- 5. Bearing retainer
- 6. Front bearing
- 7. Front bracket

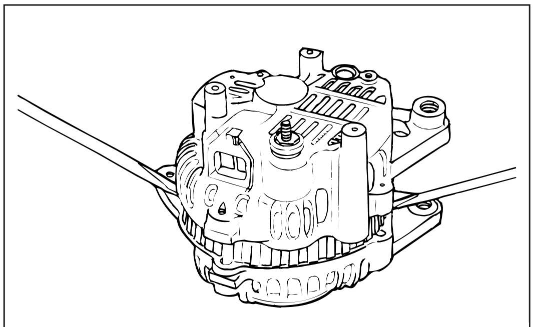
Disassembly steps (Continued)

- <<**C**>> 8. Stator
- 9. Plate
- <<**C**>> >>**A**<< 10. Regulator assembly
- 11. Brush
- 12. Rubber packing
- 13. Rectifier
- 14. Rear bracket

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DISASSEMBLY SERVICE POINTS

<<A>> FRONT BRACKET ASSEMBLY REMOVAL

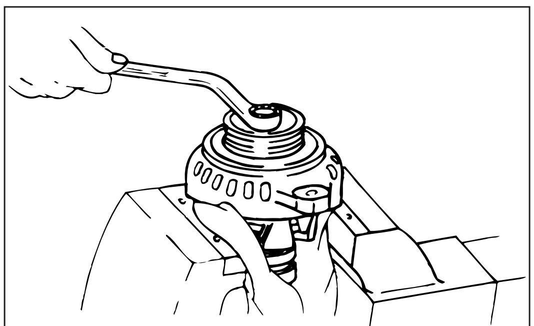

AK202718

⚠ CAUTION

Do not insert the screwdriver blades too deep. Doing so could damage the stator coil.

Insert the blades of screwdrivers between the front bracket assembly and stator core, and pry and separate them with the screwdrivers.

<<B>> ALTERNATOR PULLEY REMOVAL

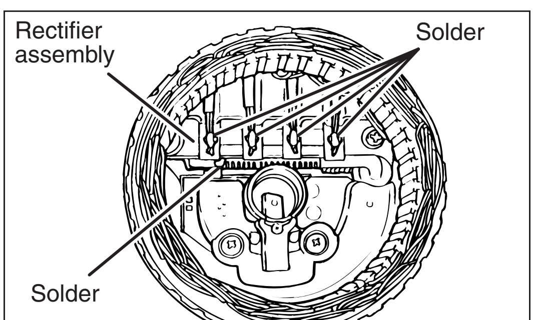

AK202714

⚠ CAUTION

Perform operation carefully not to damage the rotor.

Clamp the rotor in a vise with the pulley facing up to remove the pulley.

<<C>> STATOR / REGULATOR ASSEMBLY REMOVAL



AK202778AB

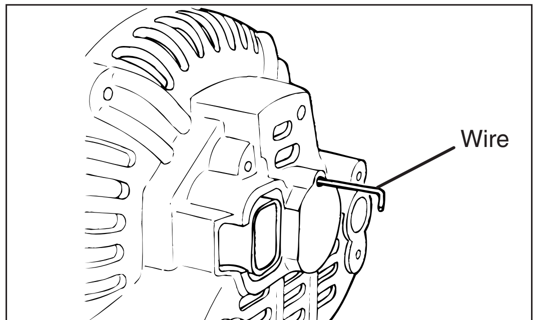
⚠ CAUTION

- **Use a 180 – 250 W soldering iron, and finish unsoldering within four seconds. Diodes will be damaged by heat if unsoldering time is too long.**
- **Avoid applying undue force to the diode leads.**

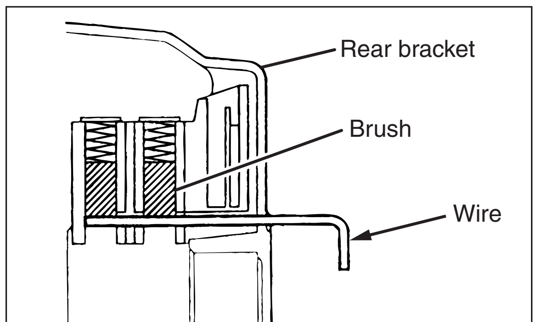
1. Unsolder the stator leads from the main diode of the rectifier assembly when the stator is removed.
2. When removing the rectifier assembly from the regulator assembly, undo the soldered points on the rectifier assembly.

REASSEMBLY SERVICE POINTS

>>A<< REGULATOR ASSEMBLY INSTALLATION



AK202779AB



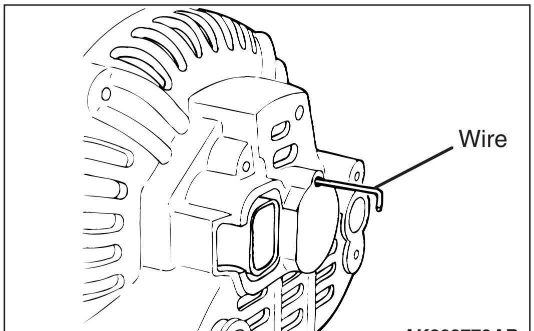
AK202830AB

After installing the regulator assembly, insert a piece of wire through the hole in the rear bracket while pressing the brush to keep the brush against movement.

NOTE: Holding the brush with the wire facilities installation of the rotor.

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Group TOC

>>B<< ROTOR INSTALLATION



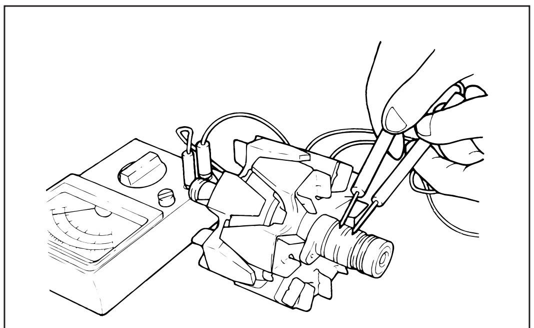
AK202779AB

Remove the brush holding wire after the rotor has been installed.

INSPECTION

M1161001700248

ROTOR



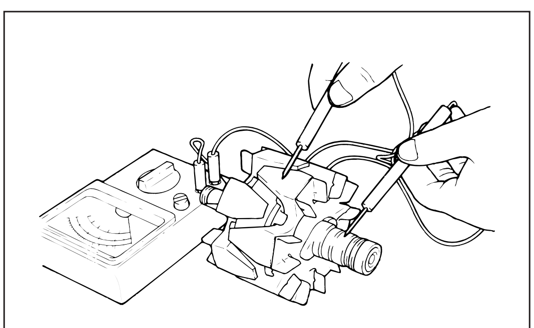
AK202735

1. Measure the resistance between the two slip rings of the rotor coil to check the continuity between them.

   Replace the rotor if the resistance is not within the standard value range.

   Standard value: 2 – 4 Ω

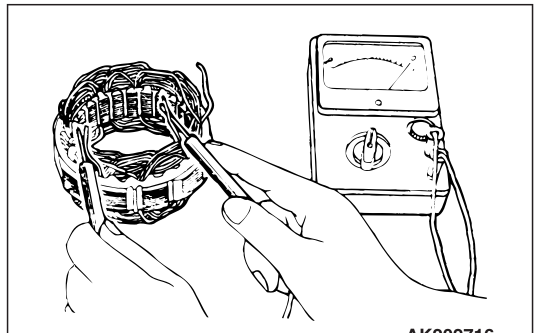
2. Check the continuity between the slip rings and core.



AK202736

3. If continuity is present, replace the rotor.

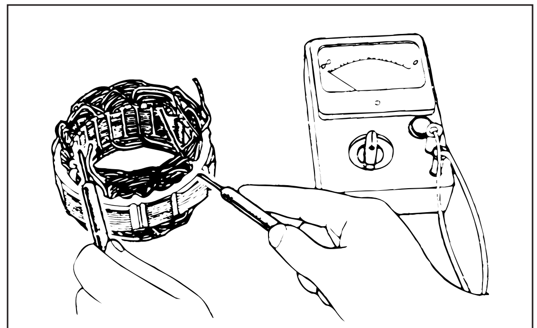
STATOR



AK202716

1. Check the continuity between coil leads.

   If there is no continuity, replace the stator.

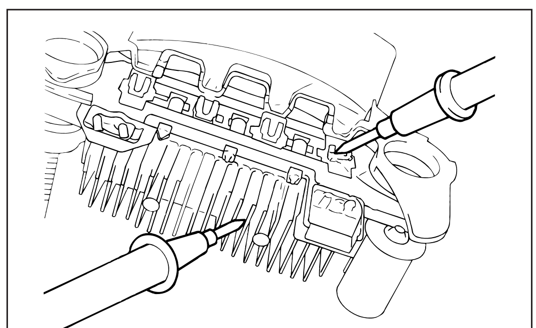


AK202717

2. Check the continuity between coil and core.

   If there is no continuity, replace the stator.

RECTIFIER ASSEMBLY

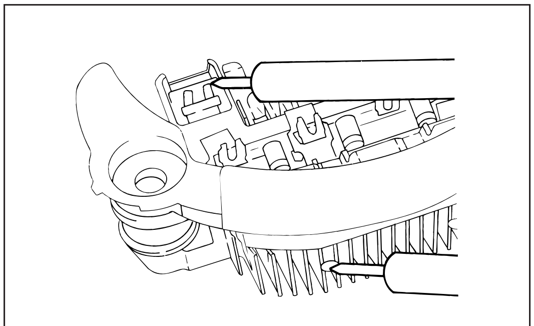


AK202803

1. Check the condition of the (+) heat sink by checking continuity between the (+) heat sink and each of the stator coil lead connecting terminals.

   If continuity is present for both terminals, the diode is shorted. Replace the rectifier assembly.

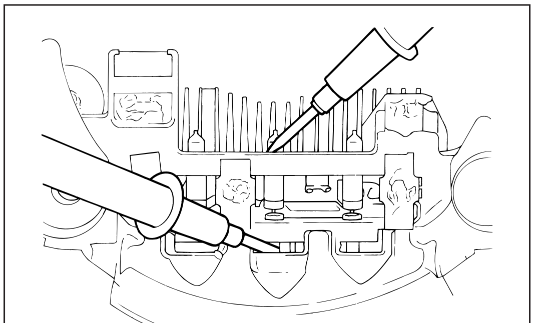
Main Index
Group TOC



AK202802

2. Check the condition of the (–) heat sink by checking continuity between the (–) heat sink and each of the stator coil lead connecting terminals.

   If continuity is present in both directions, the diode is shorted. Replace the rectifier assembly.

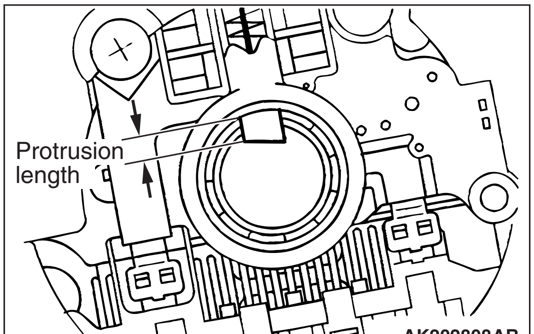


AK202804

3. Check the condition of the diode trio by testing continuity of each of the three diodes using a circuit tester connected to both sides of the diode. Connect in a polarity and then reverse the polarity for each test.

   If continuity exists or no continuity exists for both polarities, the diode is defective. Replace the rectifier assembly if any of the diodes is defective.

BRUSH

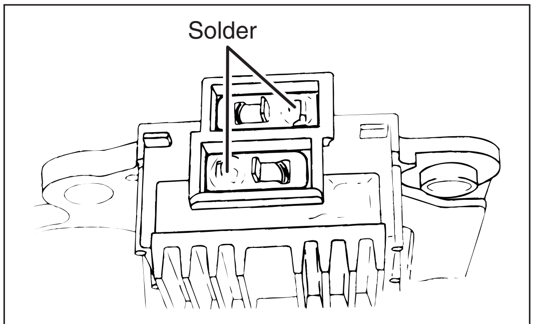


AK202808AB

1. Measure the length of the protrusion of the brush. Replace the brush if the protrusion length is shorter than the limit.

   Limit: 2 mm minimum

2. Unsolder the lead of the brush. The brush will come out, becoming ready for removal.



AK202834AB

3. Install a new brush by pushing it into the holder as shown in the drawing and soldering the lead.

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Group TOC

STARTING SYSTEM

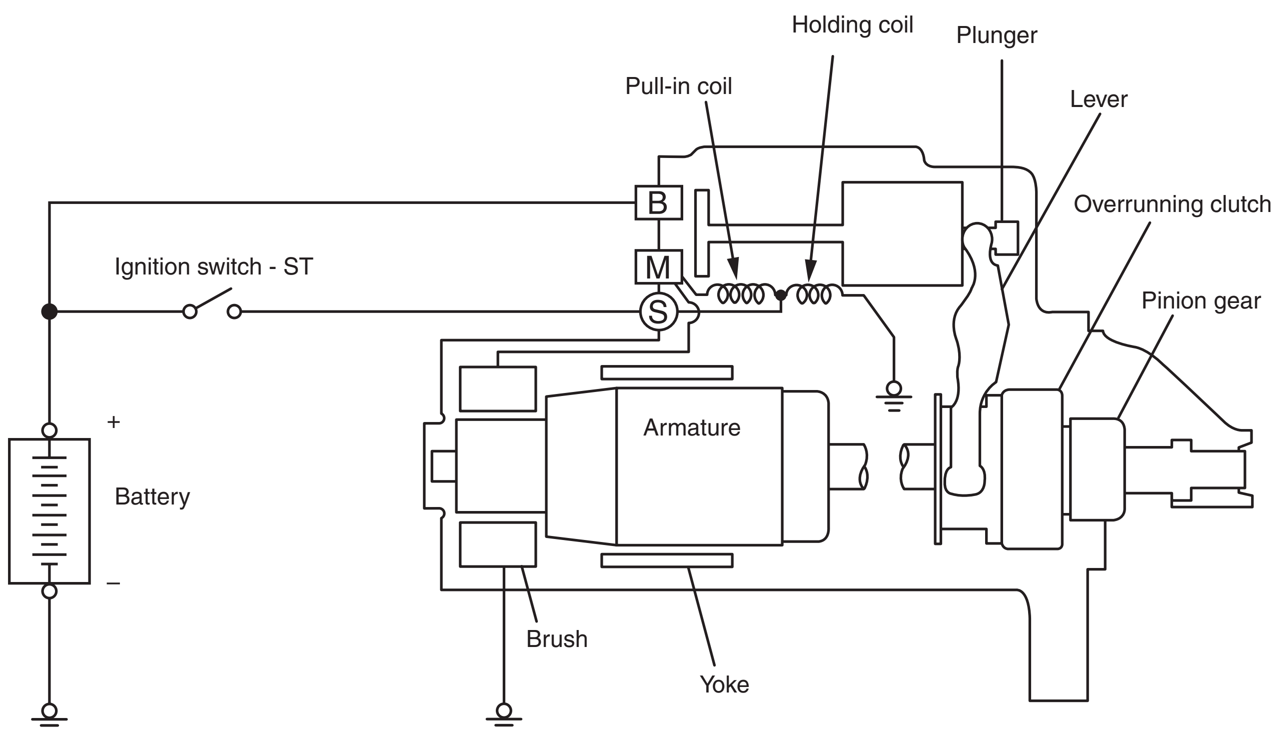
GENERAL INFORMATION

M1162000100592

If the ignition switch is turned to the "START" position, current flows in the pull-in and holding coils provided inside magnetic switch, attracting the plunger, When the plunger is attracted, the lever connected to the plunger is actuated to engage the starter clutch. On the other hand, attracting the plunger will turn on the magnetic switch, allowing the "B" terminal and "M" terminal to conduct. Thus, current flows to engage the starter motor.

When the ignition switch is returned to the "ON" position after starting the engine, the starter clutch is disengaged from the ring gear.
An overrunning clutch is provided between the pinion and the armature shaft, to prevent damage to the starter.

SYSTEM DIAGRAM



AK202970 AD

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Group TOC

STARTER MOTOR SPECIFICATIONS

Item		Specifications
Type		Reduction drive with planetary gear
Rated output kW/V	<M/T>	0.9/12
	<CVT>	1.2/12
Number of pinion teeth	<M/T>	8
	<CVT>	10

SERVICE SPECIFICATIONS

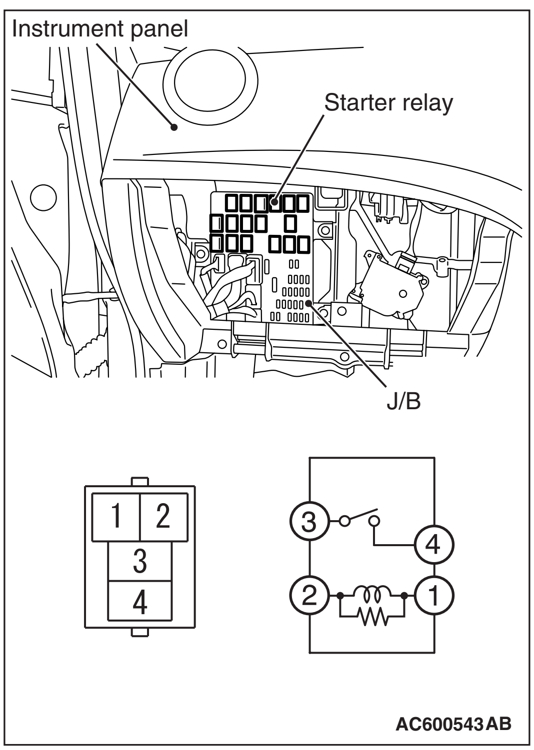
M1162000300143

Item	Standard value	Limit
Pinion gap mm	0.5 – 2.0	–
Commutator run-out mm	0.05	0.1
Commutator diameter mm	29.4	28.8
Undercut depth mm	0.5	0.2

ON-VEHICLE SERVICE

STARTER RELAY CONTINUITY CHECK <M/T>

M1162001400488



Battery voltage	Terminal No. to be connected to tester	Continuity test results
Not applied	3 – 4	Open circuit
Connect terminal No.2 and battery (+) terminal. Connect terminal No.1 and battery (–) terminal.		Continuity (less than 2 Ω)

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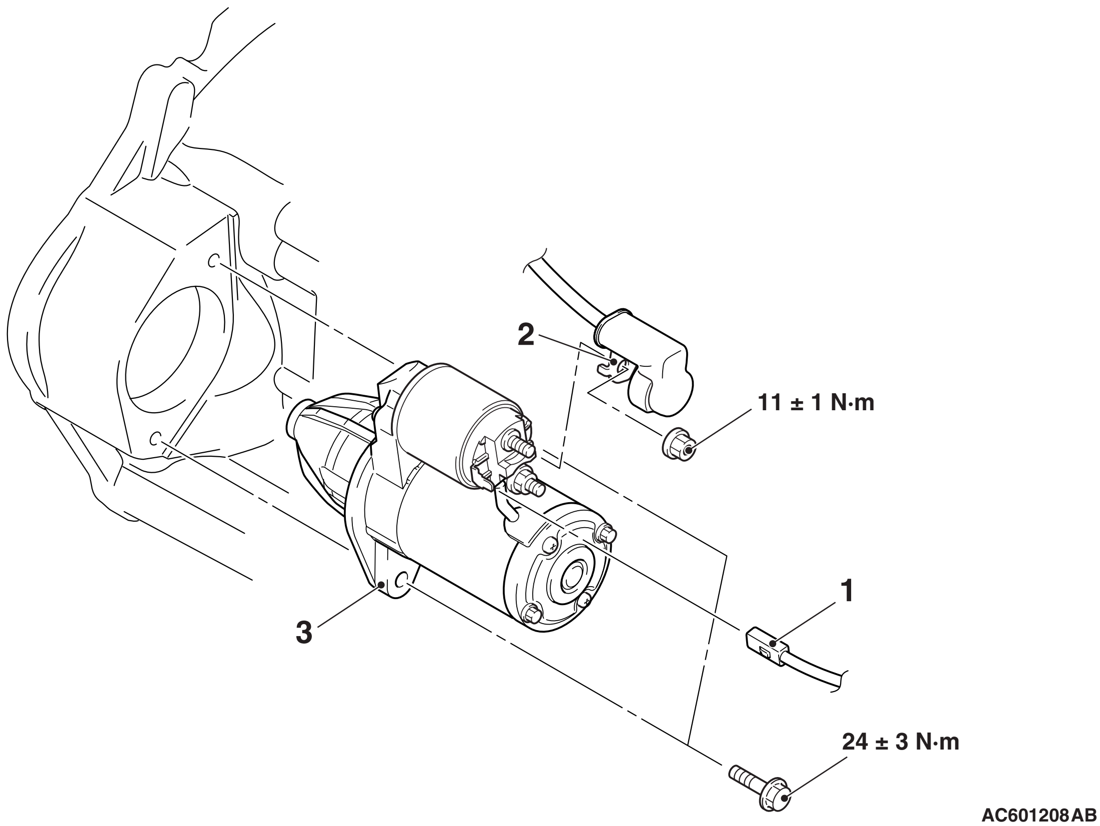
STARTER MOTOR ASSEMBLY

REMOVAL AND INSTALLATION <4A9>

M1162001001610

Pre-removal Operation	Post-installation Operation
• Front Under Cover Panel Removal (Refer to GROUP 51, Front Bumper Assembly and Radiator Grille P.51-2).	• Front Under Cover Panel Installation (Refer to GROUP 51, Front Bumper Assembly and Radiator Grille P.51-2).

<M/T>



Removal steps

1. Starter connector

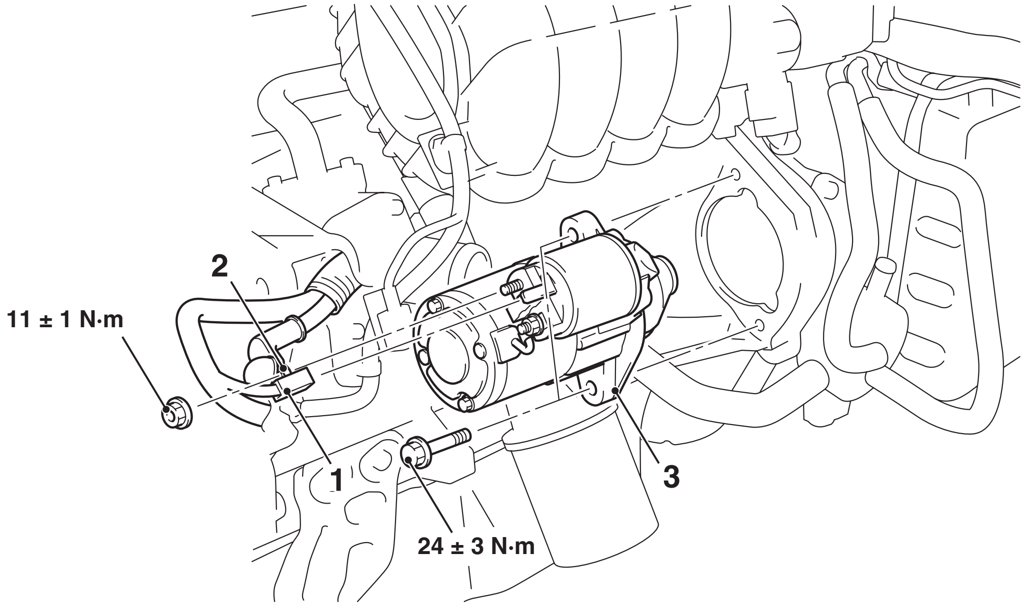
Removal steps (Continued)

2. Starter terminal

<<**A**>> 3. Starter assembly

Main Index
Group TOC

<CVT>



Removal steps

1. Starter connector
2. Starter terminal

<<**A**>> 3. Starter assembly

REMOVAL SERVICE POINT

<<A>>STARTER ASSEMBLY REMOVAL

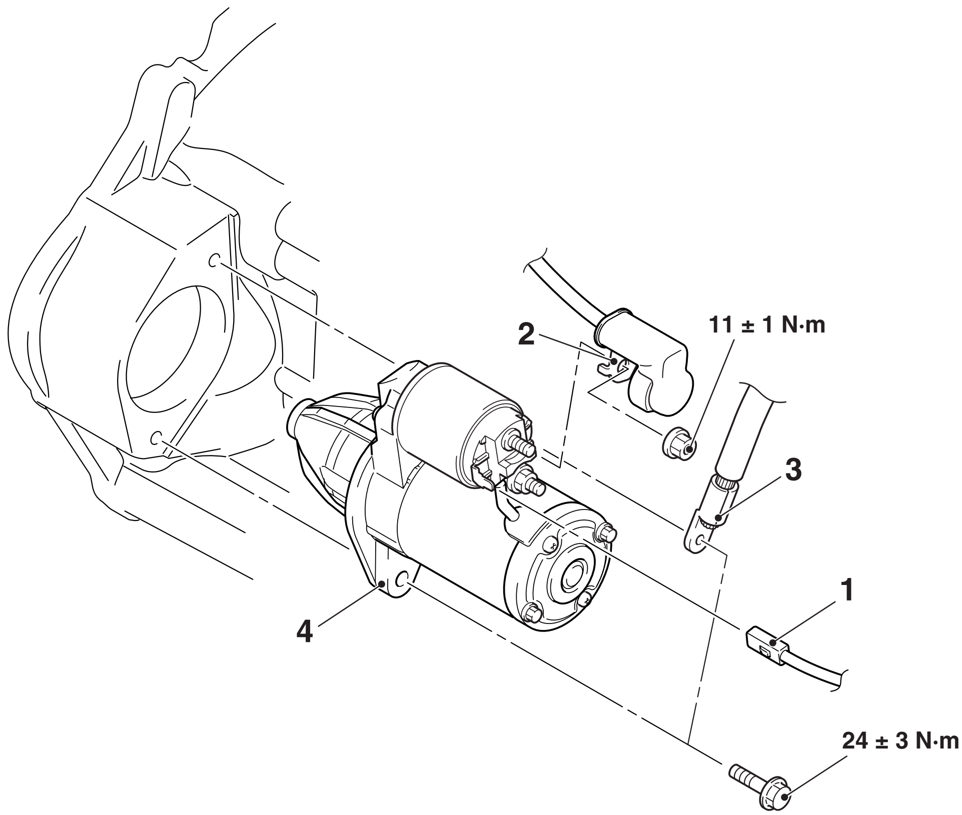
Remove each starter mounting bolt and remove the starter assembly from underneath the vehicle.

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REMOVAL AND INSTALLATION <4G1>

M1162001001643

Pre-removal Operation	Post-installation Operation
• Front Under Cover Panel Removal (Refer to GROUP 51, Front Bumper Assembly and Radiator Grille P.51-2). • Air Hose A Removal (Refer to GROUP 15, Intercooler P.15-8).	• Air Hose A Installation (Refer to GROUP 15, Intercooler P.15-8). • Front Under Cover Panel Installation (Refer to GROUP 51, Front Bumper Assembly and Radiator Grille P.51-2).



Removal steps

1. Starter connector
2. Starter terminal
3. Earth connection

<<**A**>> 4. Starter assembly

REMOVAL SERVICE POINT

<<A>>STARTER ASSEMBLY REMOVAL

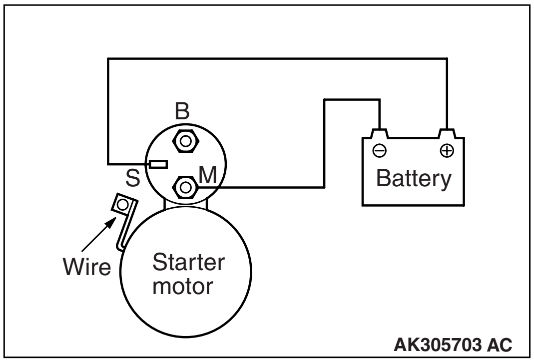
Remove each starter mounting bolt and remove the starter assembly from underneath the vehicle.

STARTER MOTOR ASSEMBLY INSPECTION <4A9>

M1162001100476

<M/T>

MAGNETIC SWITCH PULL-IN TEST

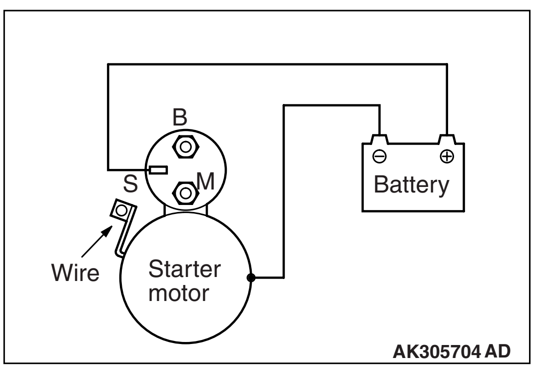


1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

⚠ CAUTION
This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

2. Connect a 12-volt battery between the S-terminal and M-terminal.
3. If the pinion moves out, the pull-in coil is good. If it doesn't, replace the starter motor.

MAGNETIC SWITCH HOLD-IN TEST

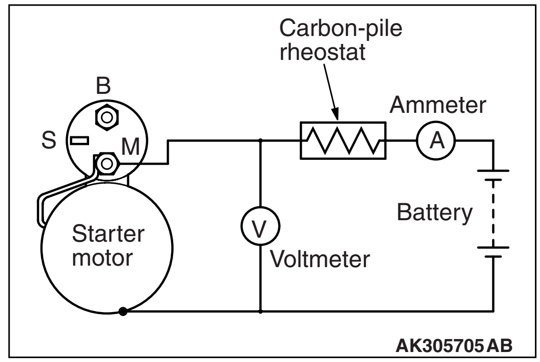


1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

⚠ CAUTION
This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

2. Connect a 12-volt battery between the S-terminal and body.
3. Manually pull out the pinion as far as the pinion stopper position.
4. If the pinion remains out, everything is in order. If the pinion moves in, the hold-in circuit is open. Replace the starter motor.

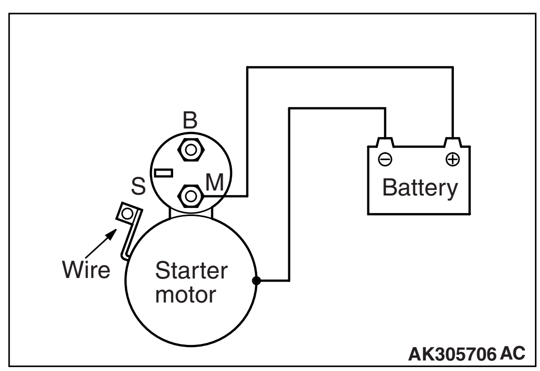
FREE RUNNING TEST



1. Place the starter motor in a vise equipped with soft jaws and connect a fully-charged 12-volt battery to the starter motor as follows:
2. Connect a test ammeter (100-ampere scale) and carbon pile rheostat in series between the battery (+) terminal and starter motor terminal.
3. Connect a voltmeter (15-volt scale) across the starter motor.
4. Rotate the rheostat to full-resistance position.
5. Connect the battery cable from the battery (-) terminal to the starter motor body.
6. Adjust the rheostat until the battery voltage shown on the voltmeter is 11.5 V.
7. Confirm that the maximum amperage is within the specifications and that the starter motor turns smoothly and freely.

   Current:
   maximum 40 Amps

MAGNETIC SWITCH RETURN TEST



1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

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Group TOC

⚠ CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

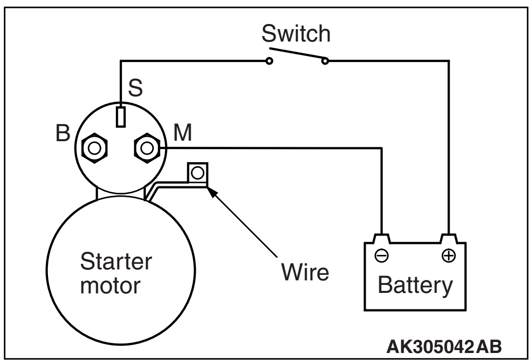
2. Connect a 12-volt battery between the M-terminal and body.

⚠ WARNING

Be careful not to get your fingers caught when pulling out the pinion.

3. Pull the pinion out and release. If the pinion quickly returns to its original position, everything is operating properly. If it doesn't, replace the starter motor.

<CVT>
PINION GAP ADJUSTMENT

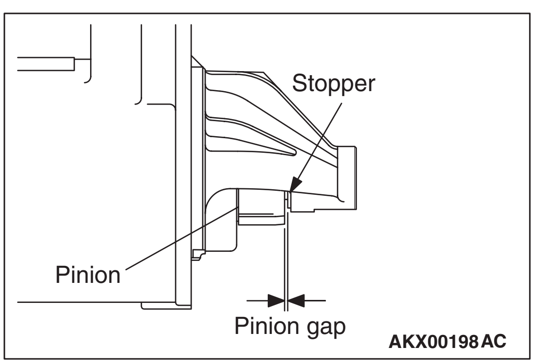


1. Disconnect the field coil wire from the M-terminal of the magnetic switch.
2. Connect a 12-volt battery between the S-terminal and M-terminal.

⚠ CAUTION

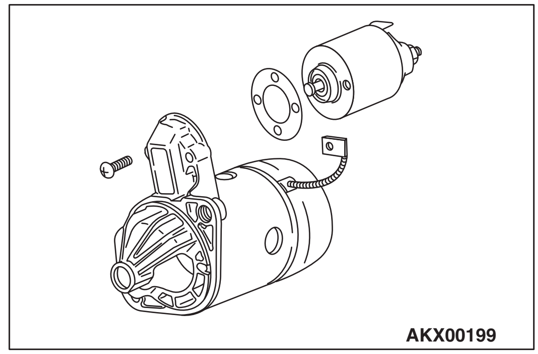
This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

3. Set the switch to "ON", and the pinion will move out.



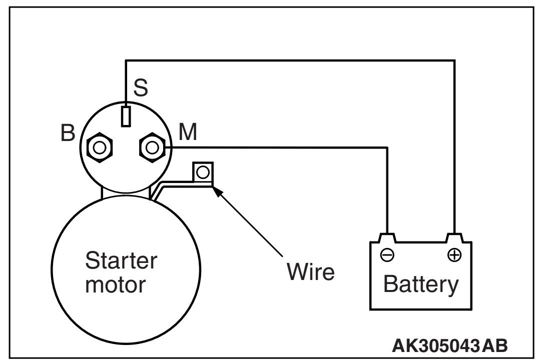
4. Check the pinion-to-stopper clearance (pinion gap) with a feeler gauge.

Standard value: 0.5 – 2.0 mm



5. If the pinion gap is out of specification, adjust by adding or removing gasket(s) between the magnetic switch and front bracket.

MAGNETIC SWITCH PULL-IN TEST



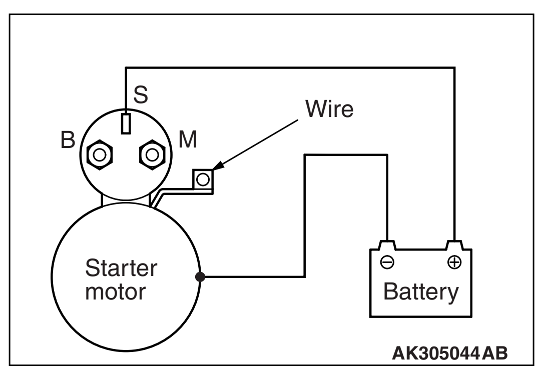
1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

⚠ CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

2. Connect a 12-volt battery between the S-terminal and M-terminal.
3. If the pinion moves out, the pull-in coil is good. If it doesn't, replace the magnetic switch.

MAGNETIC SWITCH HOLD-IN TEST



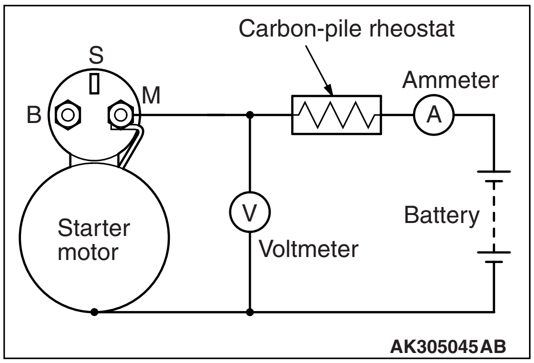
1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

⚠ CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

2. Connect a 12-volt battery between the S-terminal and body.
3. Manually pull out the pinion as far as the pinion stopper position.
4. If the pinion remains out, everything is in order. If the pinion moves in, the hold-in circuit is open. Replace the magnetic switch.

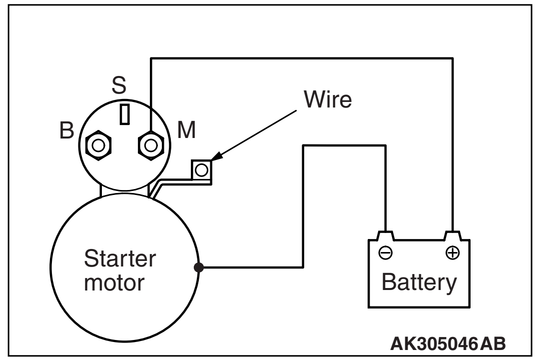
FREE RUNNING TEST



1. Place the starter motor in a vise equipped with soft jaws and connect a fully-charged 12-volt battery to the starter motor as follows:
2. Connect a test ammeter (100-ampere scale) and carbon pile rheostat in series between the battery (+) terminal and starter motor terminal.
3. Connect a voltmeter (15-volt scale) across the starter motor.
4. Rotate the rheostat to full-resistance position.
5. Connect the battery cable from the battery (-) terminal to the starter motor body.
6. Adjust the rheostat until the battery voltage shown on the voltmeter is 11 V.
7. Confirm that the maximum amperage is within the specifications and that the starter motor turns smoothly and freely.

   Current:
   maximum 95 Amps

MAGNETIC SWITCH RETURN TEST



1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

⚠ CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

2. Connect a 12-volt battery between the M-terminal and body.

⚠ *WARNING*

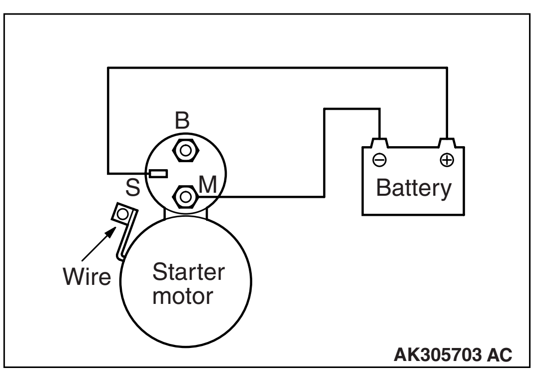
Be careful not to get your fingers caught when pulling out the pinion.

3. Pull the pinion out and release. If the pinion quickly returns to its original position, everything is operating properly. If it doesn't, replace the magnetic switch.

STARTER MOTOR ASSEMBLY INSPECTION <4G1>

M1162001100498

MAGNETIC SWITCH PULL-IN TEST



1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

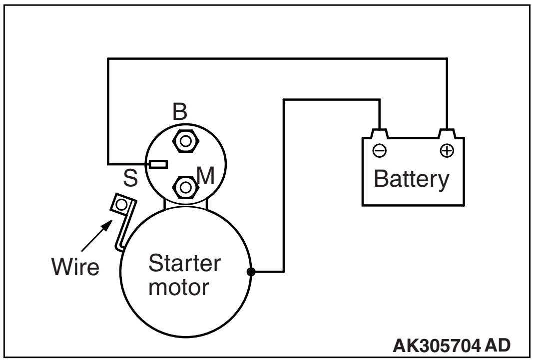
⚠ CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

2. Connect a 12-volt battery between the S-terminal and M-terminal.
3. If the pinion moves out, the pull-in coil is good. If it doesn't, replace the starter motor.

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MAGNETIC SWITCH HOLD-IN TEST



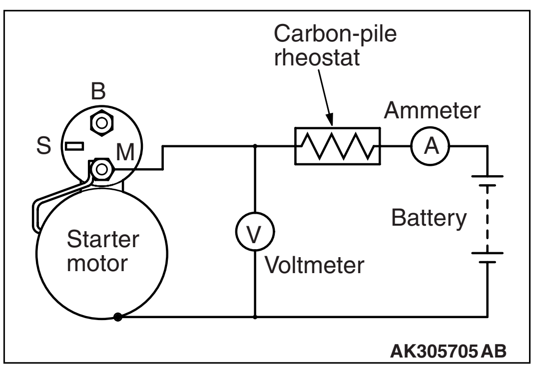
1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

⚠ CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

2. Connect a 12-volt battery between the S-terminal and body.
3. Manually pull out the pinion as far as the pinion stopper position.
4. If the pinion remains out, everything is in order. If the pinion moves in, the hold-in circuit is open. Replace the starter motor.

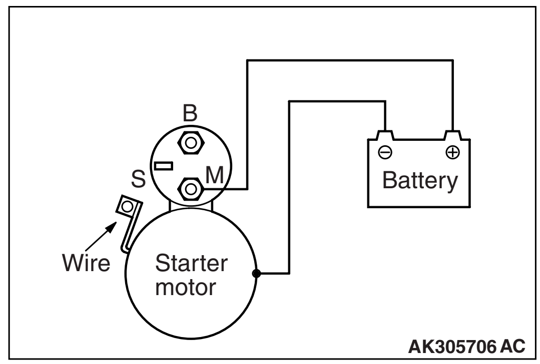
FREE RUNNING TEST



1. Place the starter motor in a vise equipped with soft jaws and connect a fully-charged 12-volt battery to the starter motor as follows:
2. Connect a test ammeter (100-ampere scale) and carbon pile rheostat in series between the battery (+) terminal and starter motor terminal.
3. Connect a voltmeter (15-volt scale) across the starter motor.
4. Rotate the rheostat to full-resistance position.
5. Connect the battery cable from the battery (-) terminal to the starter motor body.
6. Adjust the rheostat until the battery voltage shown on the voltmeter is 11.5 V.
7. Confirm that the maximum amperage is within the specifications and that the starter motor turns smoothly and freely.

Current:
maximum 40 Amps

MAGNETIC SWITCH RETURN TEST



1. Disconnect the field coil wire from the M-terminal of the magnetic switch.

⚠ CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

2. Connect a 12-volt battery between the M-terminal and body.

⚠ *WARNING*

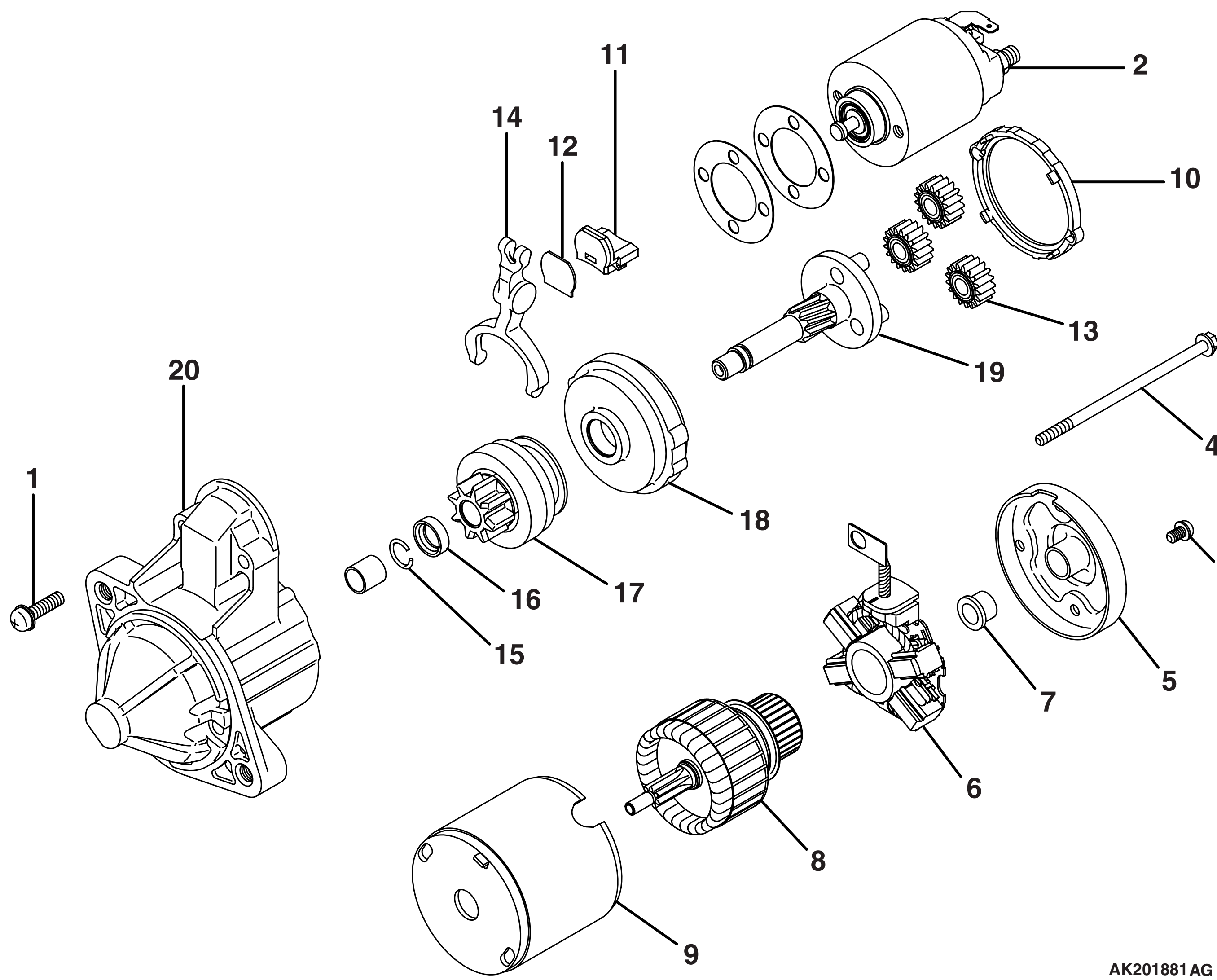
Be careful not to get your fingers caught when pulling out the pinion.

3. Pull the pinion out and release. If the pinion quickly returns to its original position, everything is operating properly. If it doesn't, replace the starter motor.

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DISASSEMBLY AND ASSEMBLY

M1162001200451



Disassembly steps

1. Screw
<<**A**>> 2. Magnetic switch
3. Screw
4. Bolt
5. Rear bracket
6. Brush holder
7. Rear bearing
8. Armature
9. Yoke assembly
10. Packing A

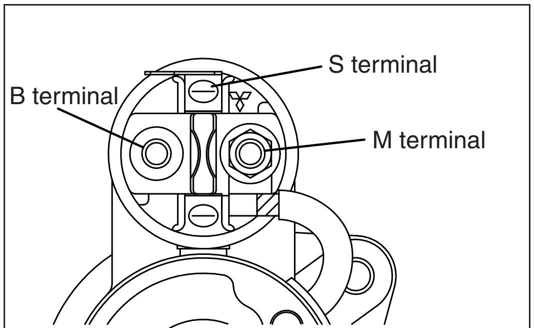
Disassembly steps (Continued)

11. Packing B
12. Plate
13. Planetary gear
14. Lever
<<**B**>> >>**A**<< 15. Snap ring
<<**B**>> >>**A**<< 16. Stop ring
17. Overrunning clutch
18. Internal gear
19. Planetary gear shaft
20. Front bracket

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DISASSEMBLY SERVICE POINTS

<<A>> MAGNETIC SWITCH REMOVAL



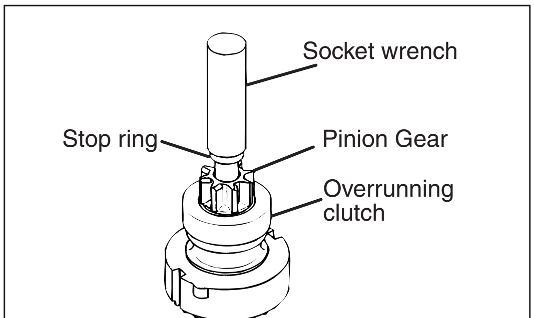
AK201882AC

⚠ CAUTION

Do not clamp the yoke assembly with a vise.

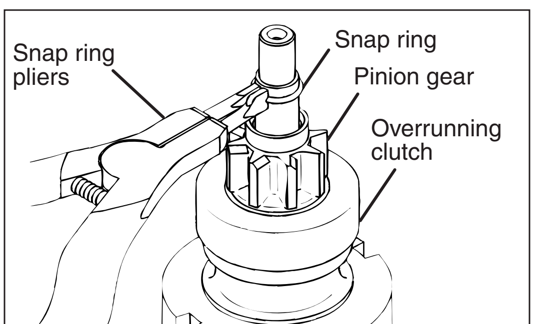
Disconnect the lead from the M terminal of the magnetic switch.

<<B>> SNAP RING/STOP RING REMOVAL



AK202790AB

1. Apply a long socket wrench of an appropriate size to the stop ring and strike the wrench to drive out the stop ring toward the pinion gear side.



AK202791AB

2. Remove the snap ring with snap ring pliers, then remove the stop ring and overrunning clutch.

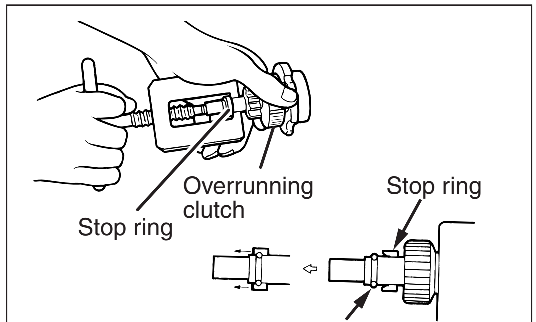
STARTER MOTOR PARTS CLEANING

Never clean in a solvent such starter motor parts as the magnetic switch, brush holder, and armature. If they are soaked in a solvent, their insulation could be impaired. When these parts require cleaning, wipe off contamination with cloth.

1. Never soak the drive unit in a solvent. If it is washed in a solvent, the grease having been packed in the overrunning clutch at the factory will be washed out. Wipe the drive unit with cloth if it requires cleaning.

REASSEMBLY SERVICE POINTS

>>A<< STOP RING/SNAP RING INSTALLATION



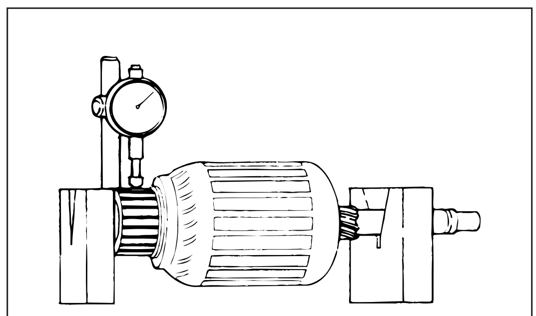
AK202911AB

Use a suitable puller to pull the stop ring until it gets over the snap ring.

INSPECTION

M1162001300265

COMMUTATOR

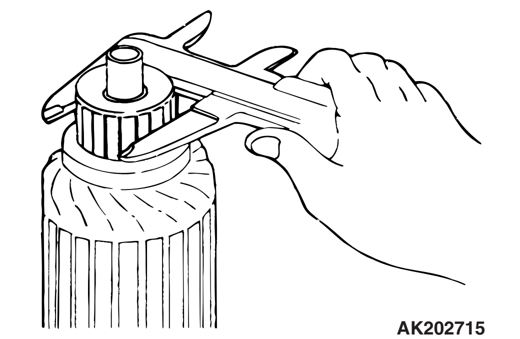


AK202712

1. Support the armature with a pair of V block and turn it to measure the runout of the surface not rubbed by the brushes using a dial gauge.

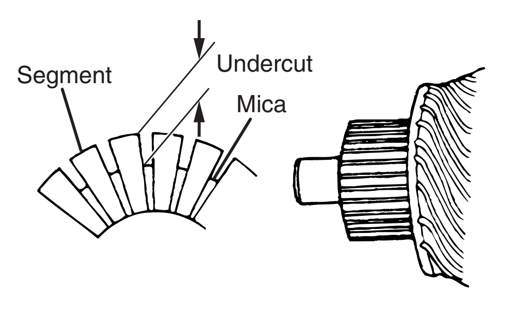
   Standard value: 0.02 mm or less
   Limit: 0.05 mm

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AK202715

2. Measure the diameter of the commutator.

Standard value: 29.4 mm
Limit: 28.8 mm

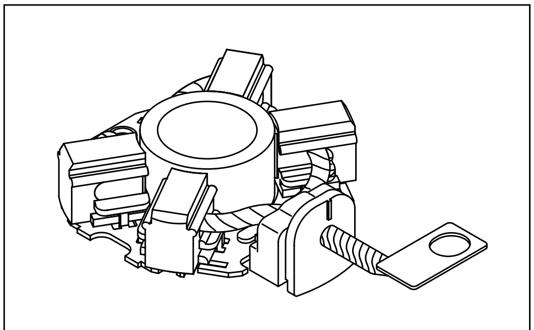


AK202711AB

3. Measure the depth of the undercut between segments.

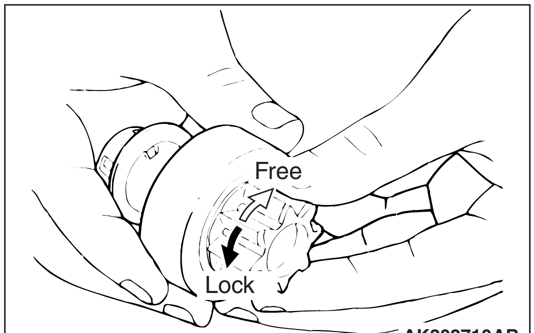
Standard value: 0.5 mm
Limit: 0.2 mm

BRUSH HOLDER


AK201187

Push the brush into the brush holder to make sure that the spring is working on the brush.
If the spring is not working, replace the brush holder.

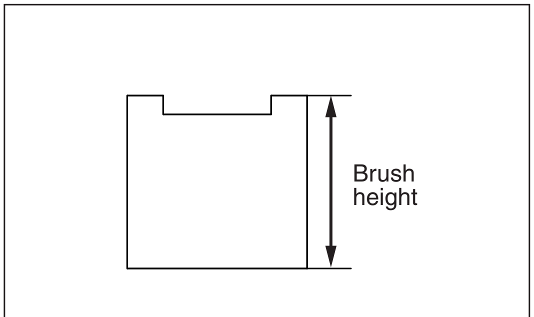
OVERRUNNING CLUTCH



AK202710AB

1. Make sure that the pinion cannot be turned counterclockwise and can be turned clockwise freely.
2. Check the pinion for abnormal ware and damage.

BRUSHES



AK202846AB

1. Check the commutator contacting surface of each brush for abnormal roughness. Also check the height of the brush. Replace the brush holder if the height is lower than the limit.

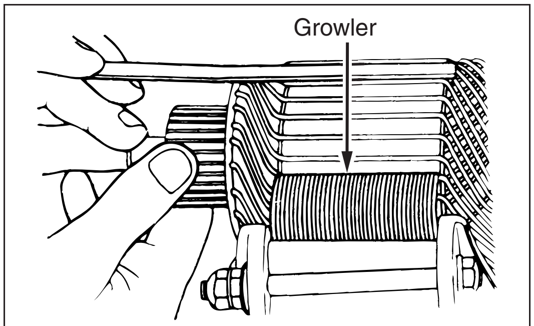
   Limit: 5.5 mm

2. When the contact surface of the brush is rectified or the brush holder is replaced, recondition the contact surface with sandpaper wrapped around the commutator.

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ARMATURE COIL

1. Check the armature coil for short circuit as follows:



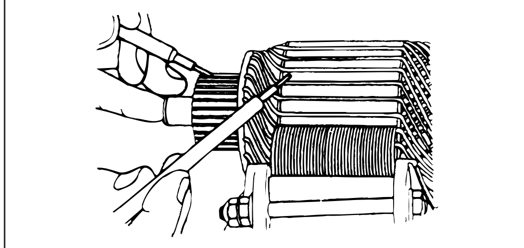
AK202733AB

2. Set the armature in a growler.

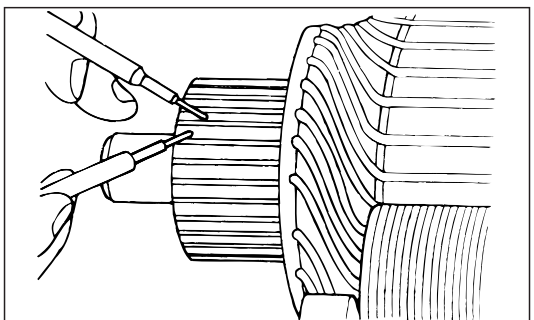
⚠ CAUTION

Clean the surface of the armature thoroughly before performing the test.

3. While holding a thin strip of iron against the armature in parallel with its axis, turn the armature slowly. The armature is normal if the iron strip is not attracted to the armature or it does not vibrate.

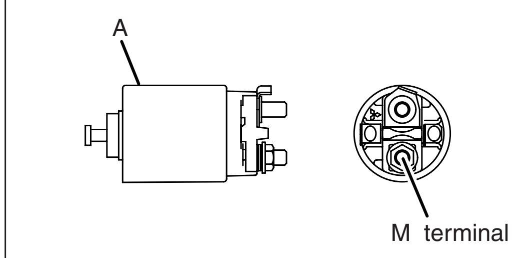

AK202734

4. Check the insulation between commutator segments and armature coils. The armature coils are properly insulated if no continuity is present.


AK202713

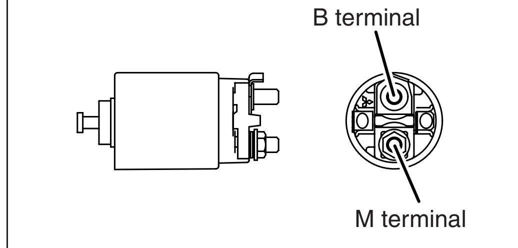
5. Check continuity between a segment and another. There is no open circuit in the tested coil if there is continuity.

MAGNETIC SWITCH



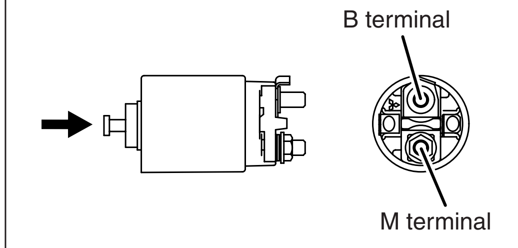
AK202891AB

1. Coil open circuit test
   - Check that there is continuity between the M terminal and body A.
   - If there is no continuity, replace the magnetic switch.



AK202892AB

2. Contact fusion check
   - Check that there is no continuity between the B terminal and M terminal.
   - If there is continuity, replace the magnetic switch.



AK202893AB

3. Switch contact check
   - Push the indicated end of the magnetic switch with a strong force to close the internal contacts. Without releasing the switch end, check that there is continuity between the B terminal and M terminal.
   - If there is no continuity, replace the magnetic switch.

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IGNITION SYSTEM

GENERAL INFORMATION

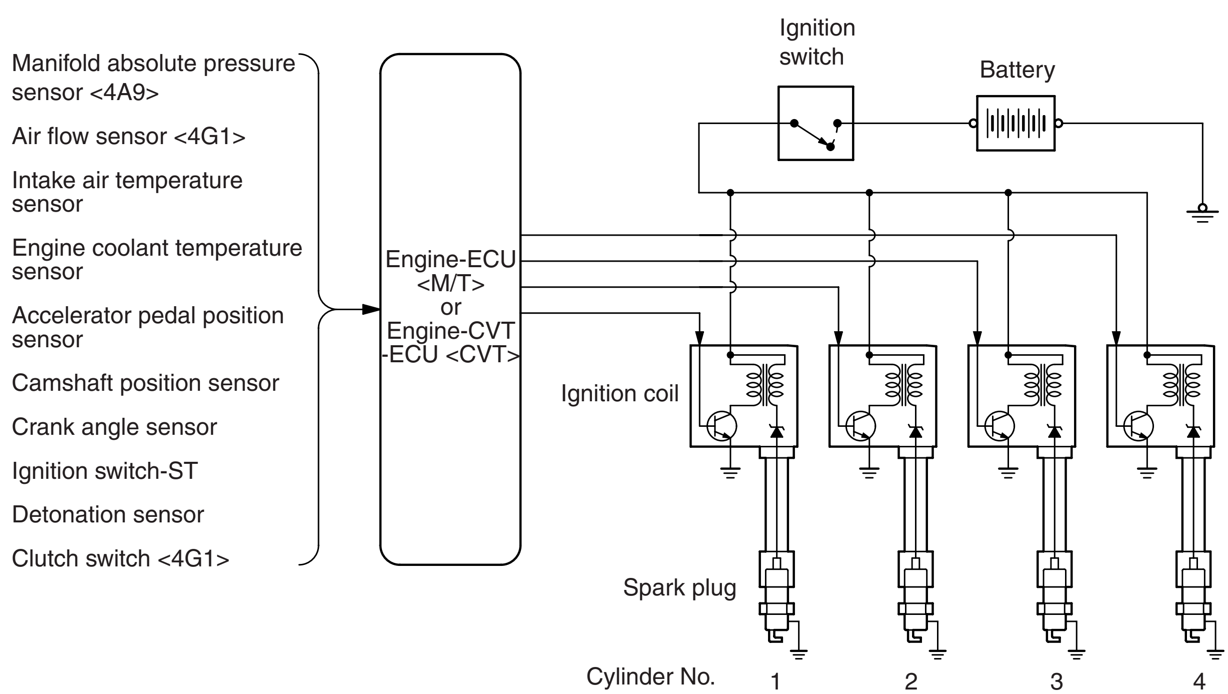
M1163000100711

This system is equipped with four ignition coils with built-in power transistors for each of the cylinders. Interruption of the primary current flowing in the primary side of an ignition coil generates a high voltage in the secondary side of ignition coil. The high voltage thus generated is applied to the spark plugs to generate sparks. The engine-ECU <M/T> or engine-CVT-ECU <CVT> turns the power transistors inside the ignition coils alternately on and off.This causes the primary currents in the ignition coils to be alternately interrupted and allowed to flow to fire the cylinders in the order 1-3-4-2.

The engine-ECU <M/T> or engine-CVT-ECU <CVT> determines which ignition coil should be controlled by means of the signals from the camshaft position sensor and the crank angle sensor. It also detects the crankshaft position, in order to provide ignition at the most appropriate timing in response to the engine operation conditions.

When the engine is cold or running at high altitudes, the ignition timing is slightly advanced to provide optimum performance. Furthermore, if knocking occurs, the ignition timing is gradually retarded until knocking ceases.

SYSTEM DIAGRAM



AK600740AB

IGNITION COIL SPECIFICATION

Item	Specification
Type	Molded 4-coil

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SPARK PLUG SPECIFICATIONS

Item	Specification
BOSCH <4A9>	FR7SI30
NGK <4G1>	IZFR6C-K

SERVICE SPECIFICATIONS

M1163000300373

SPARK PLUG

Item		Standard value	Limit
Spark plug gap mm	4A9	1.0 – 1.1	1.4
	4G1	0.7 – 0.8	0.95

SEALANT <4A9>

M1163000500043

Item	Specified sealant	Remark
Cylinder block	LOCTITE 5971 or exact equivalent	Semi-drying sealant

ON-VEHICLE SERVICE

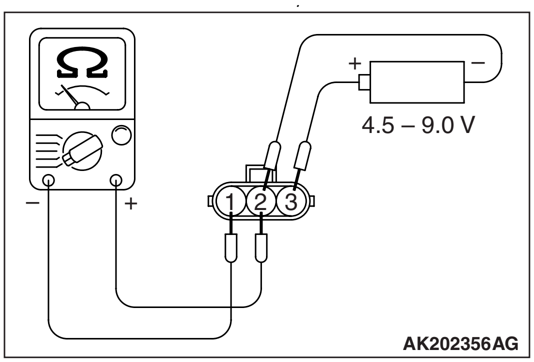
IGNITION COIL (WITH BUILT-IN POWER TRANSISTOR) CHECK

M1163001200711

Check by the following procedure, and replace if there is a malfunction.

PRIMARY COIL AND POWER TRANSISTOR CONTINUITY CHECK

NOTE:



An analogue-type circuit tester should be used.

- *Connect the negative (-) prove of the circuit tester to terminal No. 1.*

⚠ **CAUTION**

This test must be performed quickly (in less than 10 seconds) to prevent coil from burning and power transistor from breakage.

Connect and disconnect 4.5 – 9.0 V battery between terminal No. 2 and No. 3, and observe the ohmmeter whether there is continuity or not.

4.5 – 9.0 V power supply between 2 – 3	Continuity between 1 – 2
When current is flowing	Continuity
When current is not flowing	No continuity

SECONDARY COIL CHECK

NOTE: It is impossible to check the secondary coil through the continuity check as a diode is integrated in the secondary coil circuit of this ignition coil. Accordingly, check the secondary coil in the following procedure.

1. Disconnect the ignition coil connector.
2. Remove the ignition coil and install a good spark plug to the ignition coil.
3. Connect the ignition coil connector.
4. Earth the side electrode of the spark plug and crank the engine.
5. Check that spark is produced between the electrodes of the spark plug.
6. If no spark plug is produced, replace the ignition coil with a good one and recheck.
7. If spark is produced with the good ignition coil, replace the old one as it is faulty. If no spark is produced again, the ignition circuit is suspected as faulty. Check the ignition circuit.

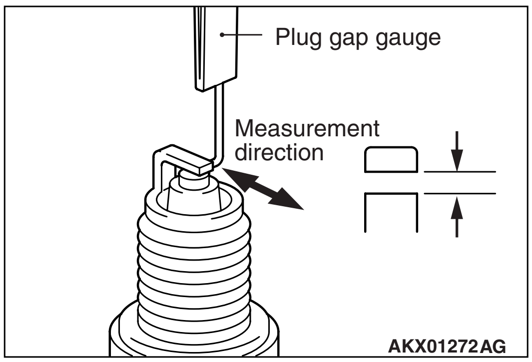
SPARK PLUG CHECK AND CLEANING

M1163004300933

⚠ CAUTION
- **Never attempt to adjust the gap of the iridium plug.**
- **Do not attempt to clean the spark plug because it may result in damage to the electrode. However, if remarkable carbon deposits must be removed, using a plug cleaner, complete the cleaning within 20 seconds to protect the electrode. Do not use a wire brush.**

NOTE: As the prospective distance for this spark plug replacement is 100,000 km. If the plug gap and insulation resistance are normal, check the plug state and clean it if necessary.

SPARK PLUG GAP CHECK

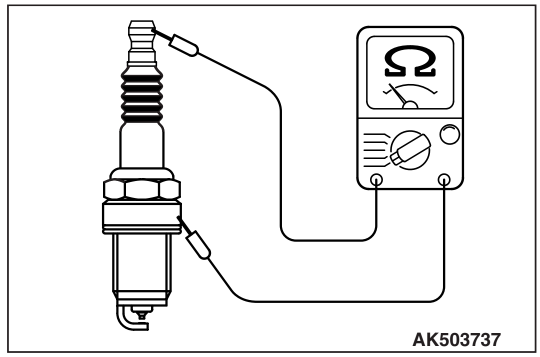


Check the plug gap with the wire type plug gap gauge. Replace it if the limit is exceeded.

Standard value, limit:

Manufacturer	Type	Standard value (mm)	Limit (mm)
BOSCH <4A9>	FR7SI30	1.0 – 1.1	1.4
NGK <4G1>	IZFR6C-K	0.7 – 0.8	0.95

SPARK PLUG INSULATION RESISTANCE CHECK



1. Measure the insulation resistance. If the insulation resistance of the spark plug is not within the limited value, clean the plug within 20 seconds using a plug cleaner.
2. After cleaning, measure the insulation resistance again. Replace the plug unless it is within the limited value.

   Limit: 10 MΩ

CAMSHAFT POSITION SENSOR CHECK

M1163004400576

Check the camshaft position sensor circuit if self-diagnosis code No. P0340 is shown.

(Refer to GROUP 13A – Troubleshooting – Inspection chart for diagnosis code P.13A-20 <4A9>, GROUP 13B – Troubleshooting – Inspection chart for diagnosis code P.13B-18 <4G1>).

CRANK ANGLE SENSOR CHECK

M1163004500636

Check the crank angle sensor circuit if self-diagnosis code No. P0335 is shown.

(Refer to GROUP 13A – Troubleshooting – Inspection chart for diagnosis code P.13A-20 <4A9>, GROUP 13B – Troubleshooting – Inspection chart for diagnosis code P.13B-18 <4G1>).

DETONATION SENSOR CHECK

M1163002900285

Check the detonation sensor circuit if self-diagnosis code No. P0325 is shown.

(Refer to GROUP 13A – Troubleshooting – Inspection chart for diagnosis code P.13A-20 <4A9>, GROUP 13B – Troubleshooting – Inspection chart for diagnosis code P.13B-18 <4G1>).

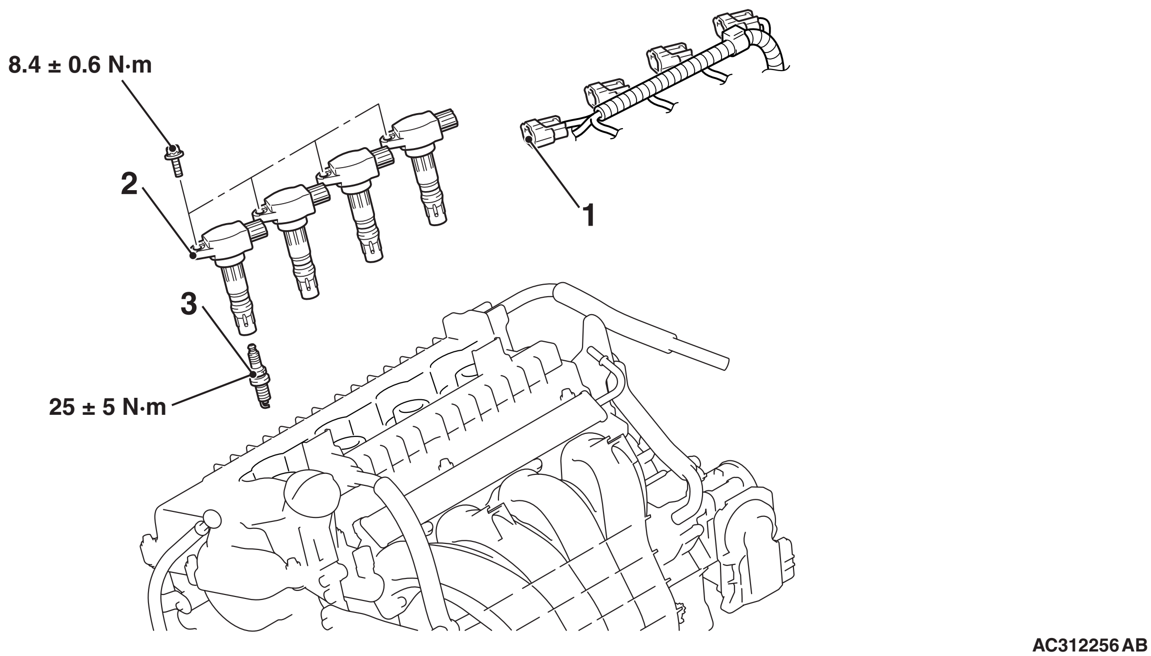
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IGNITION COIL

REMOVAL AND INSTALLATION <4A9>

M1163004000783

Pre-removal Operation	Post-installation Operation
• Engine Cover Removal (Refer to GROUP 11A, Camshaft P.11A-17).	• Engine Cover Installation (Refer to GROUP 11A, Camshaft P.11A-17).



Removal steps

1. Ignition coil connectors

Removal steps (Continued)

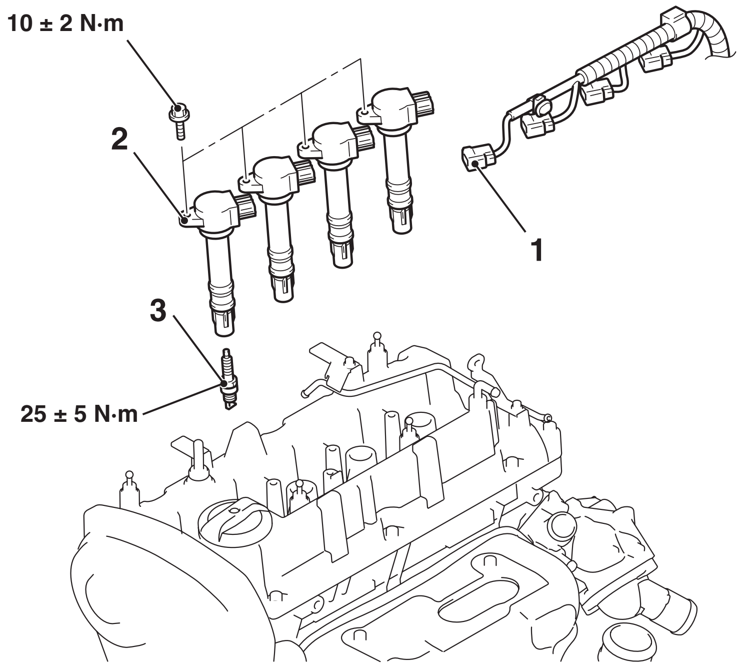
2. Ignition coils
3. Spark plugs

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Group TOC

REMOVAL AND INSTALLATION <4G1>

M1163004000794

Pre-removal Operation	Post-installation Operation
• Engine Cover Removal (Refer to GROUP 11C, Camshaft and Valve Stem Seal P.11C-20).	• Engine Cover Installation (Refer to GROUP 11C, Camshaft and Valve Stem Seal P.11C-20).



Removal steps

1. Ignition coil connectors

Removal steps (Continued)

2. Ignition coils
3. Spark plugs

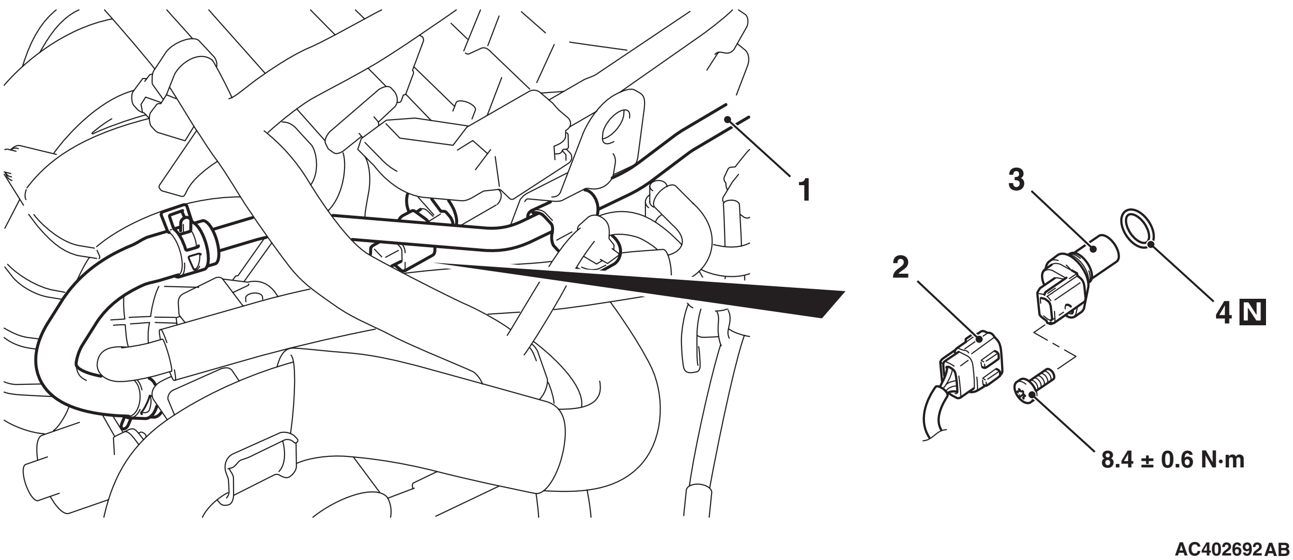
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Group TOC

CAMSHAFT POSITION SENSOR

REMOVAL AND INSTALLATION <4A9>

M1163003400960

Pre-removal Operation	Post-installation Operation
• Engine Cover Removal (Refer to GROUP 11A, Camshaft P.11A-17). • Air Cleaner Removal (Refer to GROUP 15, Air Cleaner P.15-5).	• Air Cleaner Installation (Refer to GROUP 15, Air Cleaner P.15-5). • Engine Cover Installation (Refer to GROUP 11A, Camshaft P.11A-17).



Removal steps

1. Brake booster vacuum hose and pipe assembly
2. Camshaft position sensor connector

Removal steps (Continued)

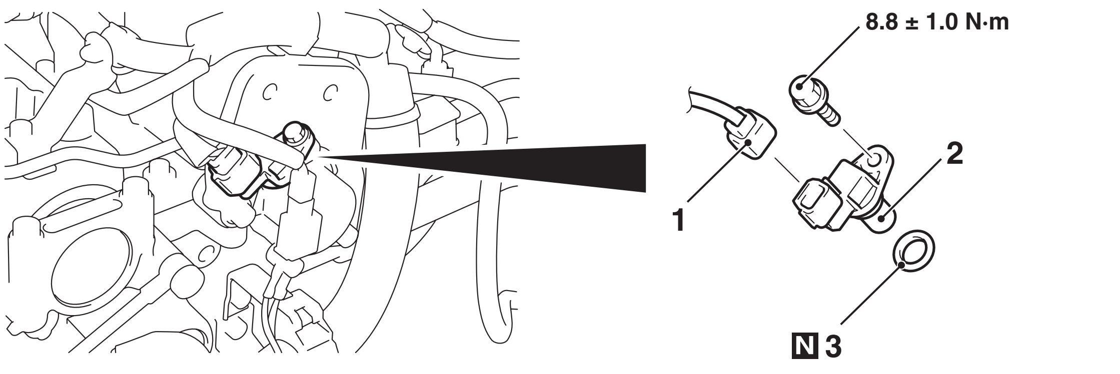
3. Camshaft position sensor
4. O-ring

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REMOVAL AND INSTALLATION <4G1>

M1163003400722

Pre-removal Operation	Post-installation Operation
• Engine Cover Removal (Refer to GROUP 11C, Camshaft and Valve Stem Seal P.11C-20). • Air Cleaner Removal (Refer to GROUP 15, Air Cleaner P.15-6). • Air Hose and Air Pipe Removal (Refer to GROUP 15, Intercooler P.15-8).	• Air Hose and Air Pipe Installation (Refer to GROUP 15, Intercooler P.15-8). • Air Cleaner Installation (Refer to GROUP 15, Air Cleaner P.15-6). • Engine Cover Installation (Refer to GROUP 11C, Camshaft and Valve Stem Seal P.11C-20).



Removal steps

1. Camshaft position sensor connector

Removal steps (Continued)

2. Camshaft position sensor
3. O-ring

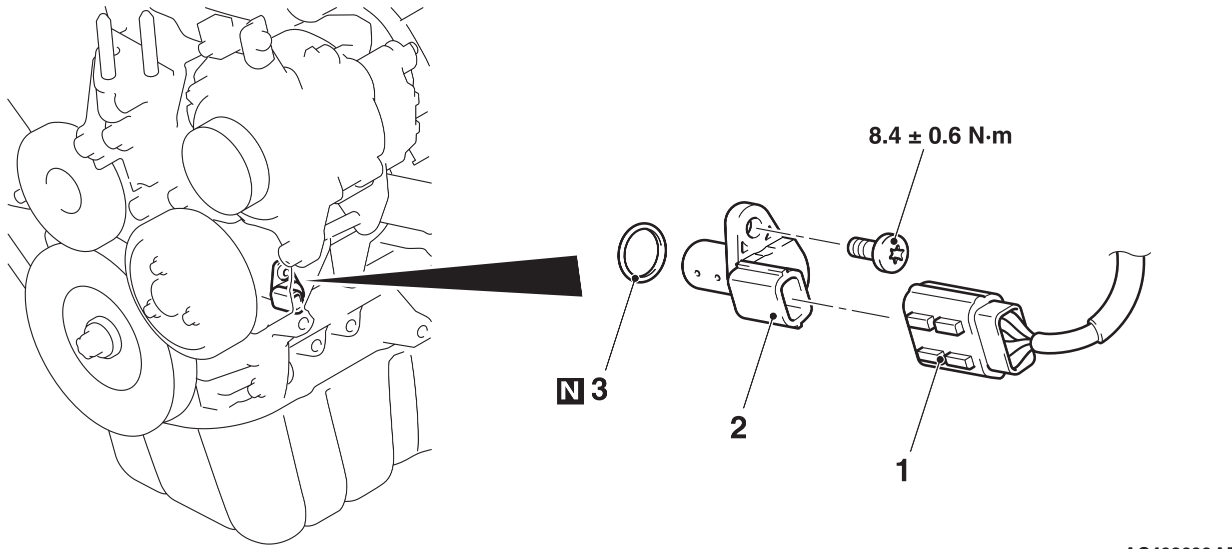
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CRANK ANGLE SENSOR

REMOVAL AND INSTALLATION <4A9>

M1163004800284

Pre-removal Operation	Post-installation Operation
• Side Under Cover Panel (RH) Removal • Drive Belt Removal (Refer to GROUP 11A, Crankshaft Pulley P.11A-14).	• Drive Belt Installation (Refer to GROUP 11A, Crankshaft Pulley P.11A-14). • Drive Belt Tension Check and Adjustment (Refer to GROUP 11A, On-Vehicle Service − Drive Belt Tension Check and Adjustment P.11A-6). • Side Under Cover Panel (RH) Installation



Removal steps

<<**A**>>		•	A/C compressor assembly
		1.	Crank angle sensor connector
	>>**A**<<	2.	Crank angle sensor
		3.	O-ring

REMOVAL SERVICE POINT

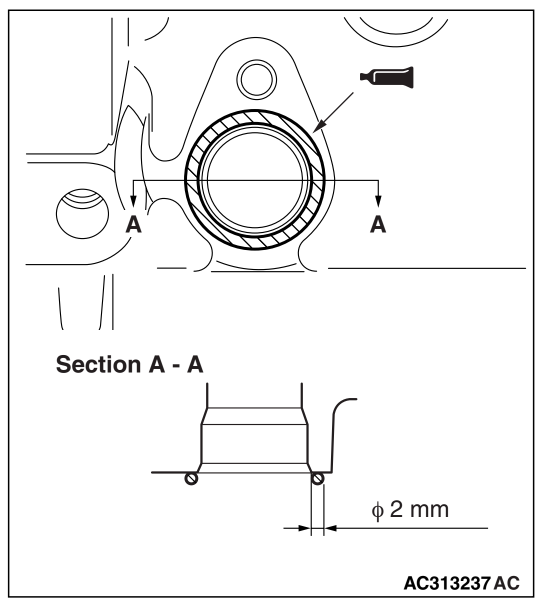
<<A>> A/C COMPRESSOR ASSEMBLY REMOVAL

1. With the hose installed, remove the A/C compressor assembly from the cylinder block (Refer to GROUP 55A, Compressor Assembly P.55A-63).
2. Secure the removed A/C compressor assembly with a cord to a place where it will not be a hindrance when removing the crank angle sensor.

INSTALLATION SERVICE POINT

>>A<< CRANK ANGLE SENSOR INSTALLATION

1. Remove sealant from the crank angle sensor and the cylinder block surfaces.



2. Apply the sealant to the cylinder block mounting surface as shown, and install the crank angle sensor to the cylinder block.

   Specified sealant: LOCTITE 5971 or exact equivalent

3. Tighten the crank angle sensor mounting bolt to the specified torque.

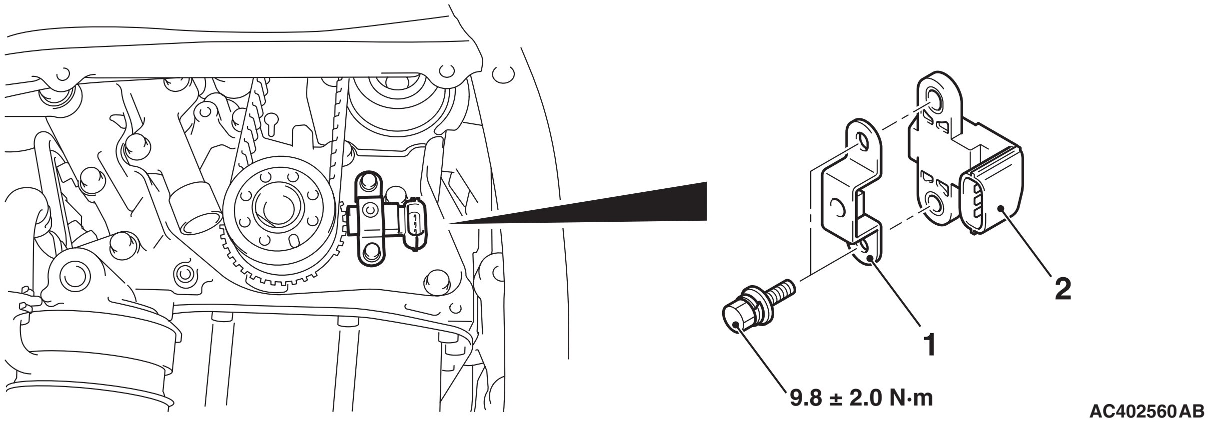
   Tightening torque: 8.4 ± 0.6 N·m

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REMOVAL AND INSTALLATION <4G1>

M1163004800295

Pre-removal Operation	Post-installation Operation
• Timing Belt Lower Cover Removal (Refer to GROUP 11C, Timing Belt P.11C-37).	• Timing Belt Lower Cover Installation (Refer to GROUP 11C, Timing Belt P.11C-37).



Removal steps

1. Timing belt lower cover bracket
2. Crank angle sensor

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Group TOC

DETONATION SENSOR

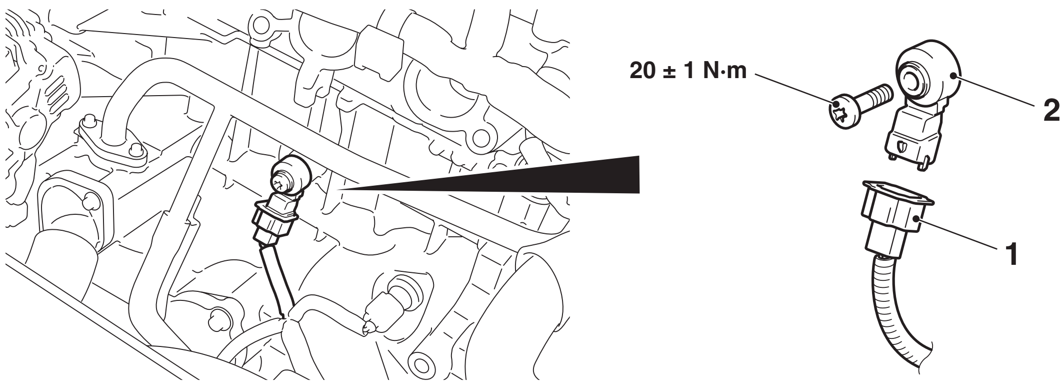
REMOVAL AND INSTALLATION <4A9>

M1163002801270

⚠ CAUTION

- **When the detonation sensor replacement is performed, use the M.U.T.-III to initialize the learning value (Refer to GROUP 00, Precautions Before Service – Initialization Procedure for Learning Value in MPI Engine P.00-20).**
- **Do not drop or hit the detonation sensor against other components. Internal damage may result, and the detonation sensor will need to be replaced.**

Pre-removal Operation	Post-installation Operation
• Inlet Manifold Removal (Refer to GROUP 15, Inlet Manifold P.15-11).	• Inlet Manifold Installation (Refer to GROUP 15, Inlet Manifold P.15-11).



AC402694AB

Removal steps

1. Detonation sensor connector
2. Detonation sensor

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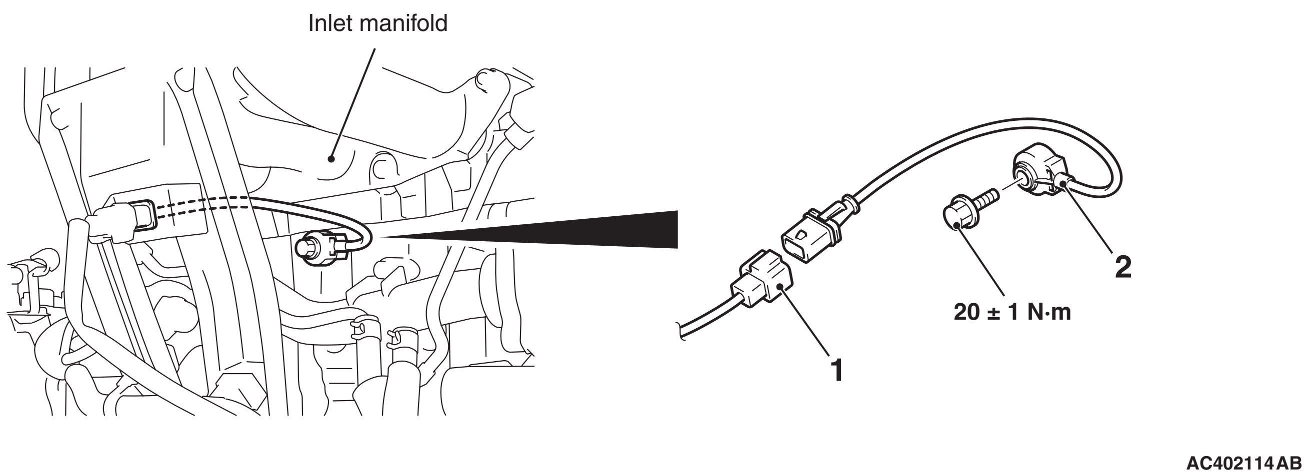
REMOVAL AND INSTALLATION <4G1>

M1163002801281

⚠ CAUTION

- **When the detonation sensor replacement is performed, use the M.U.T.-III to initialize the learning value (Refer to GROUP 00, Precautions Before Service – Initialization Procedure for Learning Value in MPI Engine P.00-20).**
- **Do not drop or hit the detonation sensor against other components. Internal damage may result, and the detonation sensor will need to be replaced.**

Pre-removal Operation	**Post-installation Operation**
• Inlet Manifold Stay Removal (Refer to GROUP 15, Inlet Manifold P.15-12).	• Inlet Manifold Stay Installation (Refer to GROUP 15, Inlet Manifold P.15-12).



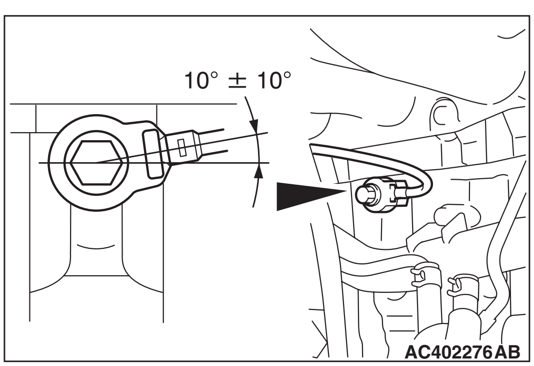
Removal steps

1. Detonation sensor connector

>>**A**<< 2. Detonation sensor

INSTALLATION SERVICE POINT

>>A<< DETONATION SENSOR INSTALLATION



1. Install the detonation sensor to the cylinder block in the area shown.
2. Tighten the detonation sensor mounting bolts to the specified torque.

Tightening torque:20 ± 1 N·m